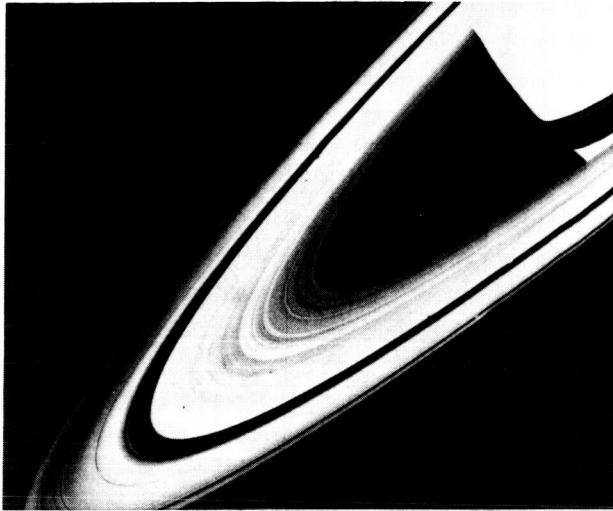
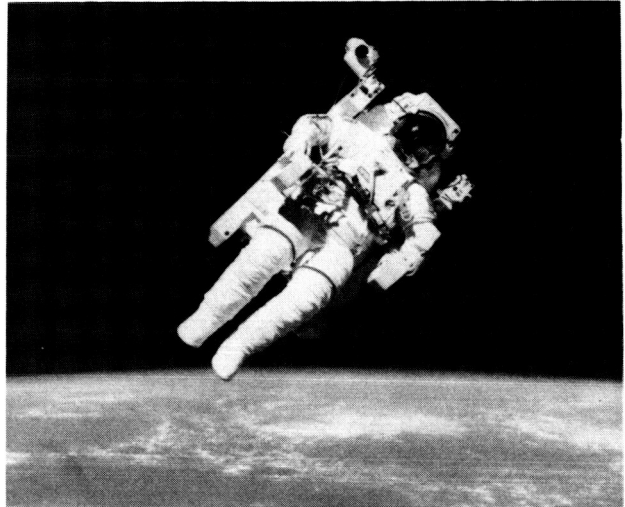


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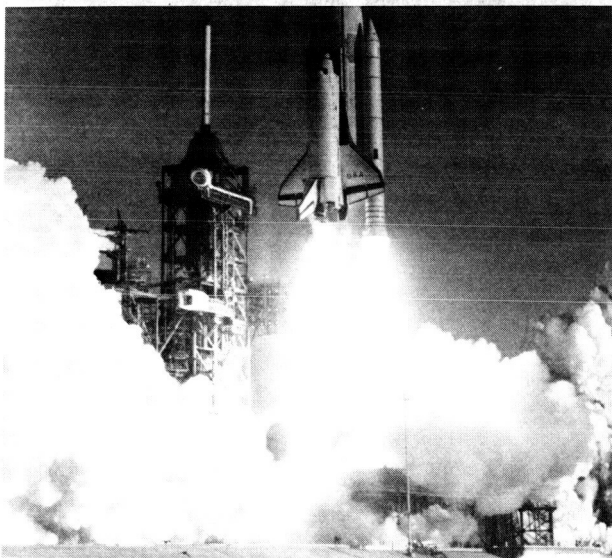
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for Quality & Productivity

NASA

National Aeronautics and
Space Administration



**1985 NASA Excellence Award for Quality
and Productivity Finalists**

Life Systems, Inc.

Martin Marietta Michoud Aerospace

McDonnell Douglas Astronautics Co.—Huntington Beach

Reynolds Metals Company—McCook Sheet & Plate Plant

Rockwell International, Space Transportation Systems Division

United Technologies, Pratt & Whitney, Government Products Division

Conducted by the
National Aeronautics and Space Administration
Office of the Chief Engineer
and the Office of NASA Productivity Programs
with the assistance of
American Society for Quality Control

May 1986

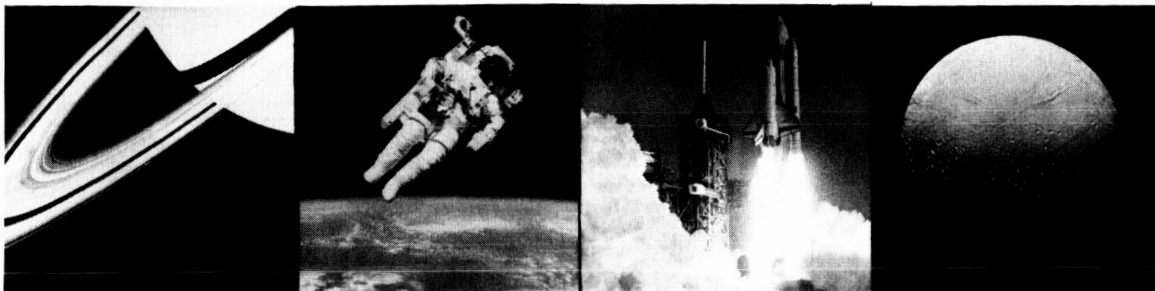


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Foreword

It is vitally important to the Nation that the National Aeronautics and Space Administration continue to emphasize productivity improvement and quality enhancement. NASA has made leadership in the development and application of practices which contribute to high quality and productivity one of its highest goals. Quality consciousness must be ingrained in our entire workforce; we must continually seek to improve our efforts. We cannot afford poor quality—it is too expensive.

To further their goals, NASA will present the NASA Excellence Award for Quality and Productivity to those aerospace companies—both large and small—whose products exemplify the highest standards of performance. The award will recognize organizations that continually seek to improve the quality of their products and services.

We recognize that an award alone cannot change organizational behavior. Only senior management attitudes and practices will influence organizational effectiveness. The NASA Excellence Award is a two-year experiment; we will determine whether it can be used to communicate to industry the kind of organization with which NASA wants to conduct business.

Quality improvement is a precursor to productivity improvement. To continue to succeed, we must give the best that is in us. Then the vision, skill, and technology that have been our trademark will continue to drive us toward even greater achievements.

Milton A. Silveira
Chief Engineer
National Aeronautics and Space Administration

Preface

The "Highlights" of the results of the NASA Excellence Award for 1985 and a summary of the submissions of the six finalists which are contained in this booklet represent the "best of the best" of NASA hardware contractors' efforts in productivity improvement and quality enhancement.

This booklet is evidence of the kind of beneficial results to be derived from the process of the Excellence Award.

This award focuses attention on the close ties among quality and success, and the productivity programs of NASA. We believe this award process, although it is only in the end of the first year of a two-year pilot period, is showing the benefits to be derived from it. It is starting to develop a learning environment for those organizations seeking to improve the quality and productivity of their products and services. This "Highlights" booklet spells success in the form of a learning tool in our first year of the Excellence Award Productivity Program.

I wish to thank the 49 NASA contractors that applied for the award and my congratulations to the six chosen finalists. With NASA Support Services contractors being added to eligibility criteria in 1986, we expect to see nearly a hundred companies participating in this important program this year. Good luck and thanks.

Harry Quong
Director
Reliability, Maintainability Quality Assurance Division
Office of the Chief Engineer
National Aeronautics & Space Administration

Introduction

The NASA Excellence Award for Quality and Productivity is the result of NASA's desire to encourage superior quality in the aerospace industry. It is awarded to NASA hardware contractors, subcontractors, and suppliers who have demonstrated sustained excellence or outstanding achievements in quality and productivity. The objectives of this award are:

- to create public awareness of the importance of quality and productivity to the United States in international economic competition;
- to encourage industry to seek excellence in products and services; and
- to promulgate the winners' methods of achieving quality and productivity excellence.

The Program is administered by American Society for Quality Control.

Because of additional workloads related to the STS 51-L Shuttle accident of January 28, 1986, the Excellence Award for Quality and Productivity will not be made for calendar 1985.

The NASA Excellence Award was to be given to NASA hardware contractors, subcontractors, and suppliers who have demonstrated sustained excellence or outstanding achievements in quality and productivity. At the time of the redirection of the 1985 awards program there were six finalists: Life Systems, Inc., Cleveland, Oh.; Martin Marietta Michoud Aerospace, New Orleans, La.; McDonnell Douglas Astronautics Co.—Huntington Beach, Cal.; Reynolds Metals Company—McCook Sheet & Plate Plant, McCook, Ill.; Rockwell International, Space Transportation Systems Division, Downey, Cal.; and United Technologies, Pratt & Whitney, Government Products Division, West Palm Beach, Fla. We congratulate them. They have made tremendous strides and are fully deserving of this recognition.

The programs that they describe, their "Highlights of Excellence," are worthy of emulation and include specific productivity improvements that should be applicable to other companies. We recommend that they be examined with a view toward adopting the ones that would improve your quality and productivity. Lessons learned are lessons gained. Also, some elements of American industry are at a critical point; they face challenges with which they have never before had to deal. Foreign manufacturers are capturing the U.S. market with offerings of high-quality products at prices the American buyer finds difficult to refuse. The depressed automobile and steel industries and the resulting imbalance of foreign trade are evidence of this formidable competition. Other factors affect the balance of trade. These are complex problems that will take time to solve and that will require the joint efforts of government and industry. It is generally agreed that a better quality U.S. product will do more than anything else to solve this problem.

In September of 1984, NASA took a positive step toward finding solutions to problems when it sponsored a Symposium on Quality and Productivity. In that two-day symposium, attended by more than 650 top executives from more than 165 corporations, government agencies, and universities, 36 speakers from highly successful organizations offered proposals for returning American business and industry to a competitive position in the world market.

In December of 1984, NASA published the "findings" of the Symposium as *A Framework for Action: Improving Quality and Productivity in Government and Industry*, which summarized the recommendations of the speakers and workshops, and organized them into the nine themes upon which the next section of this report is based. The discussions of the nine themes highlight practices and initiatives of the six finalists in the theme areas.

Following the themes section are the "Highlights of Excellence" reports provided to NASA by each of the finalists. These descriptions include specific details of Productivity Improvement and Quality Enhancement (PIQE) programs. Their successes are notable, and valuable lessons can be learned.

Challenge for the Competitive Edge: Responding to Competitive Pressures

Throughout most of this century, America was the world's unchallenged industrial and technological leader. However, during the past two decades many of us rested on our collective laurels, failing to take note of the tremendous strides being made by other nations in the areas of quality and productivity. Today we are paying the price for that inattention in the form of increasingly stiff competition in the world market. To begin to compete effectively once again, American industry must respond to those competitive pressures.

Each of the six finalist NASA contractors is responding to this pressure in a unique way. For example, Pratt & Whitney's Government Products Division has made tremendous strides against its competition through vigorous cost-reduction programs, to the extent that the average saving per employee in 1985 amounted to \$11,681.

Often, considerable expenditures are required to regain—or retain—a competitive position. Reynolds Metals Company—McCook Plant saw plant modernization and equipment upgrade as the primary means to effectively compete against the low prices of European aluminum plate and the high quality of Japanese can stock. The challenge McCook faces is to improve the appearance and quality of its product and to improve overall service to customers.

McDonnell Douglas—Huntington Beach stresses the importance of close communications with customers to better understand their needs and to respond to competitive challenges more quickly. To accomplish this goal, McDonnell Douglas has changed its Huntington Beach division from a matrix structure to Strategic Business Units. These smaller units, actually subdivisions that serve a specific market segment, such as space transportation, put employees closer to the customer, resulting in faster and more efficient service.

Life Systems considers innovation the key to its success, stressing its obligation to respond to the needs of customers with creative and innovative technological solutions. This emphasis has brought about a reduction in the complexity, weight, volume, cost, and energy requirements of products, while increasing reliability and maintainability.

Employee involvement in problem-solving and product improvement is one of the routes Rockwell International has taken to respond to competition. Employees, with the close involvement of top management, meet in Improvement Councils to discuss problems and arrive at solutions. These solutions are then implemented quickly, since approval of the Council minutes constitutes authority to act.

M. C. Bennett, Martin Marietta's vice president of financial operations, predicts that because of increased competition in the world marketplace, "by the close of the next decade our industry will consist only of those organizations that understand productivity and quality, and practice affordability." Martin Marietta has created a Commitment to Excellence process, stressing error-free performance by professionals and eliminating nonconformance in its products.

Just such a commitment to excellence is required of all American industry, both employees and management, to maintain a competitive place in the world market.

Theme 2. [REDACTED]

Make a Management Commitment to Quality and Productivity: Leading from the Top

Companies that operate under a "take the money and run" philosophy do not last long. The survivors are companies that believe in serving customers by providing the highest-quality products at reasonable prices. While this philosophy must be understood and practiced by the entire staff, from CEO to floor-worker, it must take shape at the top. Top-level management must firmly believe in the philosophy and continually reaffirm it to all employees. Management must be dedicated to incorporating those principles in its long-range objective planning.

All six of the finalists clearly practice this philosophy and their top leadership strongly support it. Some examples follow.

The chairman of the board of Reynolds Metals Company said in his statement of quality policy:

"... Each of us at Reynolds has an obligation [to our customers] to provide a quality product that will perform safely.

"No one has the right knowingly to accept or ship an unsatisfactory product.

"Quality is the fulfillment of a commitment to produce a product that meets the user's expectations, as expressed in a specification with measurable values. Such a product must be free of material defects and exemplify pride in workmanship. It must be offered at a reasonable cost and delivered on time. Finally, it must be supported with reliable and reputable service.

"The company that best satisfies these expectations wins a reputation for quality, prospers and grows, assures the security of its employees, and benefits society."

The managers and employees at McDonnell Douglas—Huntington Beach share this conviction, recognizing that the quality and productivity concept must originate and be nurtured in the top levels of management. An organization's character is, after all, in large part a reflection of its leaders' beliefs. Sandy McDonnell, chairman and CEO of McDonnell Douglas Corporation, has recorded his convictions in a corporate doctrine called The Five Keys to Self-Renewal. The keys are initiatives necessary for the growth and survival of McDonnell Douglas. Every employee is intimately familiar with the initiatives, and employees' annual performance reviews, bonuses, and raises are based on the Five Keys. Quality and productivity are at the core of this self-renewal process.

For the past three years Rockwell International has held quarterly top management reviews of progress in quality and productivity improvement. The reviews are chaired by the president and are conducted by the executives who report directly to him. Areas of discussion include improvements in product/services quality, more effective ways of doing business, and improvements in the work environment. Similar regular reviews are carried out at lower levels, all the way down to floor-level personnel. Accepted suggestions are acted upon by teams made up of employees and managers. This approach has brought top management's commitment to quality and productivity to all employees.

Mesh Goals and Responsibilities: Opening Two-Way Communications

Communication. Without it, employees are unsure of where their company is headed and the role they play; suppliers cannot be certain of what is asked of them; and customers cannot be confident that the product they receive will be the product they ordered. In short, when communication is faulty or nonexistent, serious problems occur.

Conversely, when employees, managers, vendors, and customers talk—and listen—only good things can happen.

Pratt & Whitney has found this to be the case as a result of a comprehensive employee communications plan which encourages communications among all levels and units of the company. A variety of media keeps employees informed, including employee newspapers and newsletters, videotape news shows, displays and exhibits, and general notices, as well as periodic “state-of-the-company” presentations by management.

Pratt & Whitney’s Action Line Program provides for employee complaints/inquiries to be answered by a letter from the company president or executive vice president. Employees also have access to management through informal face-to-face meetings and lunch meetings, during which managers at various levels conduct question-and-answer sessions on any issues of concern to employees.

McDonnell Douglas—Huntington Beach has established numerous communications programs, including Customer Recognition Teams (CRT) and Natural Work Groups (NWG). The CRT is formed within departments to identify the group’s internal and external customer, and their needs and concerns. The NWGs are made up of employees from different departments who meet to trade information or services. Both groups are informal and contain all levels of management and labor. Every employee participates.

With regard to external communication, Life Systems considers its subcontractors and vendors as extensions of itself and makes a special effort to convey to them the sense that they are part of the team. As a part of the team, they are expected to meet the common goals of high quality and productivity. Life Systems has developed several systems designed to communicate quality requirements. These include questionnaires, on-site visits, preliminary project-review meetings, and evaluations of past performance. Life Systems also provides its subcontractors with formal guidelines concerning quality assurance requirements.

Finally, Martin Marietta Michoud Aerospace offers some recommendations on communicating with vendors:

“Communicate early (in the bidding phase) with your management’s commitment to productivity and quality; commit his top management to a productivity improvement program; and continue the program with a productivity committee, progress reports, and face-to-face action.”

Again, the key is in the hands of top-level management. Once they have formulated their quality and productivity philosophy, they must *communicate it* clearly and repeatedly to their employees, their vendors, and their customers. When that kind of communication takes place, only success can follow.

Theme 4. [REDACTED]

Make Innovation Rewarding: Encouraging Innovation and Risk-Taking

What more fertile ground for innovation could there be than in the high-technology efforts involved in the exploration of outer space? Even for corporations not directly involved in space exploration, the explosion of modern technology offers wonderful opportunities for those willing to take calculated risks for the sake of innovation to meet the changing needs and demands of modern society.

Unfortunately, large, established organizations often tend to become conservative, refusing to take risks. That fact is one of the major causes of American industry's problems today. It is ironic that the very qualities that contribute to the founding and growth of companies—risk-taking and innovation—are the same qualities that are eventually stifled by growth and expansion.

Such is not the case with the six companies selected as finalists. Though some of them are large, well-established firms, they all pride themselves on their adventurous spirit, on constantly looking ahead, searching for new ways to do things, for new technology to help them do their jobs better. In all cases, management encourages employees to examine how they do their work and to suggest ways that it might be done better.

Life Systems, the smallest of the six finalists and only 16 years old, takes great pride in its encouragement of creative thinking, of questioning the *status quo*. According to Life Systems, they have an advantage in being small. They feel that in order to compete effectively they must take risks; they must be innovative. Realizing, however, that as a company grows it tends to lose some of its entrepreneurial spirit, Life Systems encourages the formation of independent smaller divisions as a way to assign accountability and responsibility and to maintain work environments conducive to innovative business performance.

Pratt & Whitney, a company with 60 years behind it, has no intention of letting age stifle its creative spirit. In fact, it continually encourages employees to try new ideas, to explore new concepts, and to take risks. In 1985 its highly successful employee suggestion system and cost reduction program saved the company \$93,576,339, including \$1,083,880 from quality circle suggestions.

Another success story along these lines comes from Reynolds Metals Company—McCook Plant. An extensive employee suggestion program saved, over a period of four years, eight times the cost of the project.

At Rockwell International STSD, top-level Productivity and Product Quality Improvement Councils are assigned the challenging task of reviewing the company's major systems and devising improvements. Council members are encouraged to be innovative and to challenge the *status quo*.

In today's competitive world market, risk-taking and innovation are high on the list of requirements for survival. The cliché, "Nothing ventured, nothing gained," was never truer.

Build Dedication, Pride, and Team Effort: Promoting Participative Management

This theme can be approached from two directions: top-level management and employees. Management that taps the intellectual and creative resources of its employees is wise indeed. Management that consults with the line worker before making decisions that will affect his job is twice wise. After all, who knows better how to do the job—and to suggest better ways—than the man or woman doing it?

In addition, the employee who feels that he or she has an identity and an important role to play, and who knows that when a good idea comes along someone will listen to it and act on it, is a happy, productive employee.

Each of our six finalists has a strong employee participation program that builds dedication, pride, and team effort.

Reynolds Metals Company—McCook Plant, for example, has its highly successful CHAMPS (Cooperative Hourly and Management Problem Solving) program. CHAMPS gives employees a chance to participate in making changes to their jobs, creates a vehicle to open communication, improves quality of work, reduces costs, and improves morale. During its first four years, 467 solutions were proposed, and 393 were implemented. One of every five McCook employees is on a CHAMPS team.

Rockwell International STSD has a formal system of Improvement Plans. Creative ideas are solicited from all employees and management. After review by management and entry into a computerized tracking system, these ideas become “contracts” between management and the individual or team. Rockwell is also known for its Triad of Excellence program in which areas of possible improvement become the subject matter for Improvement Councils (made up of a key management member and employee council members). These groups meet regularly to make recommendations and, eventually, to implement approved actions.

McDonnell Douglas—Huntington Beach has one of the most extensive participative management programs, including quality circles, Juran projects, a white-collar improvement program, customer recognition teams, and natural work groups.

Through the use of Quality Work Groups, Life Systems encourages team spirit. In fact, it accomplishes most of its work through teams. The majority of the company’s product development, for example, is performed by interdisciplinary teams established for work on specific programs. Project teams are formed to address various efforts to improve company operations and are the primary method of structuring Productivity Improvement and Quality Enhancement (PIQE) program activity.

Success in today’s market cannot result from the efforts of management alone. Employees represent a tremendous resource of experience and creativity that must not be overlooked. For the benefit of all, employees must be given the opportunity to participate in shaping the future of their companies.

Theme 6. [REDACTED]

Uncork Individual Talent: Controlling Bureaucracy

As organizations grow and mature, they tend to become conservative; they become bogged down in structure, in channels, and in hierarchies; they become preoccupied with controls and checks that discourage initiative and restrict creativity. Rather than searching for ways to make things happen, they seem to go out of their way to find reasons to keep them from happening.

This kind of atmosphere is foreign to Pratt & Whitney, where the emphasis is on the individual, not the bureaucracy. For example, in 1985, Pratt & Whitney's Florida operations provided special cash awards to more than 100 employees for outstanding contributions at work and in the community. Also, individuals are encouraged to submit ideas for possible patents. In 1985 individuals submitted 158 ideas for patent consideration, and the Florida facility gave cash awards to 40 employees who were notified that patents submitted in previous years had been approved by the U.S. patent office.

At the Reynolds McCook Plant, one of the more significant recent changes is the reorganization of manufacturing and maintenance departments. The purpose was to reduce reporting layers in the organization. Prior to the changes, there were seven levels between the plant manager and the equipment operator—today there are five. The results have been gratifying, especially in terms of communications, which move more quickly and with less distortion.

A second change going on at Reynolds McCook is the breaking down of "boxes." Rigidly defined areas of responsibility restrict the individual's ability to pursue problem solutions which cross over into another person's "box." Now Reynolds employees are encouraged to look beyond their routine assignments to see, for example, how a maintenance change affects the final product. The walls are still coming down, and the results are encouraging.

Believing that management must not control procedures so tightly that natural work flows are restricted, a dramatic change was made at McDonnell Douglas. It reduced their corporate procedures from 100 specific routines to 14 general guidelines that allow the employee to tailor solutions to specific problems. This allows employees the freedom to adjust their methods to the environment, without having to follow a corporate procedure on how the work *should* be done.

Even at a small, young company like Life Systems, there is danger in too much structure. Life Systems believes that flexibility is important and that some departmental restructuring/reorganization is necessary to a company as it seeks to adjust to changing needs. Employees are often assigned tasks outside their normal job scope when it is determined that expanded knowledge and skills will enable them to make greater contributions to the company.

Allowing employees greater freedom and expanding areas of responsibility is, in effect, freeing them from the restrictive chains of bureaucracy. Given the opportunity, individuals will respond positively to freedom—and to the responsibility that goes with it.

Modernize for Survival: Encouraging New Technology

The aerospace industry naturally requires the most advanced modern equipment and technology. The mission demands that the industry extend itself, continually stretching the limits of quality, productivity, and technology. The aerospace industry has an advantage over most of American industry: we have no choice but to encourage new technology.

Unfortunately, some elements of American industry have chosen to employ only "tried-and-true" techniques and equipment that have done the job well for so many years. Forward-thinking executives—including those who manage our six finalist companies—have not let that happen. They realize that as the needs of their customers change, they must change also.

As you read the rest of this booklet, you'll note that each of the six companies refers to the investments it has made in plant modernization, new heavy equipment, and new computer systems for inventory control, word processing, and design and engineering.

The engineering force at Rockwell International, for instance, utilizes computer-aided design (CAD) and sophisticated personal and mainframe computer systems. Hardware is produced and inspected in the machine shop with the aid of 45 newly installed computerized numerically controlled machines.

Life Systems is also utilizing CAD equipment to improve product quality during design changes. In addition, they have developed personal computer software which allows them to simulate both normal and abnormal operation conditions to test components and systems without risking the actual hardware.

At Martin Marietta Michoud the entire engineering data base is being converted to computer-aided three-dimensional models, the drawing/correspondence catalog and tool-inventory system are being automated. Martin Marietta is continually searching for new approaches and products by bringing together researchers from universities and research institutes, Martin Marietta personnel, and representatives from their own Advanced Manufacturing Technology Department (AMT). It is AMT's job to blend the R&D proposals and Martin Marietta's needs into practical applications as was done with the university research that provided a unique cost-saving process for the thermal protection system used on the external tank.

Reynolds Metals Company—McCook Plant, having observed the hard lessons learned in other basic metal industries, has made sweeping changes in modernizing the physical plant and equipment.

McDonnell Douglas, recognizing that it must continue to build into its organization systems of efficiency supported by the latest technology, invested \$545 million in new plants and equipment in 1985.

Likewise, Pratt & Whitney. Modernization projects include computer-aided design and manufacturing processes, a high-temperature materials laboratory in Florida, and an automated manufacturing plant in Georgia.

Our foreign competitors have made their greatest inroads in new-technology applications. The aggressive approach being taken by the six companies included here points the way for the rest of American industry.

Theme 8. [REDACTED]

Maximize Human Capital: Developing Strategies to Improve Education and Training

As noted in Theme 7, to be competitive in today's world market it is imperative that we maintain and expand our capital assets, our machines and the buildings that house them. However, we must take care never to neglect our human resource, the greatest resource at our disposal. Unless we train our employees in the care and use of the new machines, these mechanical devices will not perform at their maximum levels of capability. Neither will untrained employees.

Formerly, untrained, uneducated workers could be literally taken off the street, placed in front of a machine or alongside a conveyor belt, and within minutes be doing the job. This is no longer the case. Today's employees are expected to do much more: they must maintain the equipment, perform administrative tasks, participate in goal-setting and budgeting, and work in self-directed teams guided by principles rather than procedures.

To help employees meet the challenges of new technology, Pratt & Whitney's training department offers programs ranging from remedial assistance for less-skilled employees to advanced courses in engineering and physical science. Financial assistance is offered to employees taking courses leading to degrees at accredited educational institutions.

At Rockwell the professional staff is given advanced courses in computer-aided design (CAD) and personal computers to increase their effectiveness and productivity. Off-duty incentives have produced many degreed engineers and other specialists, which has increased Rockwell's overall technical expertise.

Twenty-five percent of Life Systems' employees took advantage of that company's self-improvement programs, ranging from tuition reimbursement to professional membership, from seminars to in-house training.

In-house training programs at Martin Marietta Michoud build task proficiency in addition to providing for personal development and growth. A planned and scheduled training and certification program provides expertise in the areas of project safety, skills/processes, tooling and facilities, and problem-solving.

Within their Productivity Improvement and Quality Enhancement (PIQE) programs, the six organizations saw and filled the need for additional instruction and training. For example, Rockwell provided each employee with a booklet describing his or her role in the Productivity and Product Quality Improvement (P&PQI) system. The training program was expanded to increase skills in group process, problem-solving, and team/individual motivational techniques.

Reynolds Metals McCook Quality Action Program included an increased emphasis on statistical process control, and the company developed a training program which involved 250 employees for an average training of nine hours each.

Because of worldwide competition and the ever-increasing complexity of modern high technology, it is no longer practical simply to urge our employees to work harder or faster. To compete and grow, we must be willing to invest considerable money—and time—to help our valued employees work *better*, improving their performance in terms of both quality and productivity.

Improve Quality/ Productivity Practices: Building a Quality Ethic

“**A**n honest day’s work for an honest day’s wages.” The Work Ethic. America has lived and prospered under it for more than 200 years. But today, while the Work Ethic still applies, American business and industry—both management and employees—must also adopt the Quality Ethic. The desire to produce the best possible product must be woven into the fabric of American industry, from CEOs to line workers. It must be constantly reiterated and incorporated in all future goal- and long-range planning. It is a matter of survival.

Sandy McDonnell’s doctrine of quality and productivity, *The Five Keys to Self-Renewal*, represents a continuous process at McDonnell Douglas—Huntington Beach. The quality emphasis has resulted in a reduction of defects per 1000 manufacturing labor hours of 61 percent and a reduction of manufacturing, such as labor hours on a particular product line, of 67 percent. For McDonnell Douglas this is a process of continuous improvement. Once the goals are achieved, new ones are set.

Pratt & Whitney is known worldwide for its “dependable engines.” This reputation is a direct result of unswerving attention to quality. In recognition of the relationship between quality and success in today’s world, Pratt & Whitney management recently initiated the Quality Plus Process which involves all employees in a comprehensive program to identify areas for potential improvement.

At Life Systems productivity and quality improvement activities are incorporated within individual programs and are managed the way any other program would be managed. Tasks are budgeted and scheduled, progress is monitored, and objectives and deliverables are stated. In essence, quality and productivity have become an inherent part of this company’s total operation.

As a measure of the effectiveness of the quality ethic fostered through PIQE programs, note that Martin Marietta Michoud decreased nonconformances by 76 percent over three years, reduced planning errors by 82 percent, improved manufacturing performance by 28 percent, and generated cost savings of more than several hundred million dollars while delivering every external tank on or ahead of schedule.

W. H. Bateman, Jr., Quality Control Manager for Reynolds McCook, describes his company’s evolving attitude toward quality: “The quality function is no longer confined to ‘an office up front.’ It is no longer just meeting specification. Quality is becoming an equal to established goals such as productivity rates and sales quotas. From the worker on the floor to the Chairman of the Board, we are learning that quality must be a way of life.”

A way of life.

We’ve been discussing quality as though it were something new. Of course, that’s not the case at all. There was a time when people took pride in their work, a time when craftsmanship was held in high esteem. We must return to that kind of ethic—the Quality Ethic.

Our six companies, their management and employees, have embraced the Quality Ethic, and the results have been remarkable.

Life Systems, Inc.

A Small Company's Success Through Innovation and Improvement

Life Systems is proud of its achievements in innovative product development and in providing quality technological solutions for the problems of space travel and space living. We have always conducted our business with the idea of being a productive and quality-conscious organization and are pleased to be partners with NASA in striving to improve productivity and quality through the PIQE program. We are using the PIQE program as a way to more effectively structure these improvement efforts, and continue committing people and money to make attainment of the program goals a reality. The results have been a strengthening of our organization to better meet the challenges of the future.

Dr. Rick A. Wynveen
President
Life Systems, Inc.

Life Systems, Inc., located in Cleveland, Ohio, is a small business compared to most NASA prime contractors, with 1985 sales of \$8.5 million. The company has successfully completed 50 NASA Research and Development (R&D) contracts and has a number of programs in progress, many of which relate to the NASA Space Station Program. The company is a high technology research, development, and production organization that has designed, engineered, and produced over 150 unique devices and products for aerospace and defense applications.

A major thrust of the company is supporting NASA in the development of advanced life support, energy storage, and propellant generating systems for the Space Station and future advanced space missions. The company takes seriously its role to provide quality technological solutions to the problems of space travel and space living.

Life Systems has provided over 16 years of regenerative life support and energy storage technology development for space flight—from basic science through prototype hardware, from mission analysis studies to advanced systems design—and has made significant contributions in regenerative air revitalization systems, regenerative water reclamation systems, and

the regenerative energy storage portion of the power supply system.

The company also produces Space Shuttle hardware. Two of Life Systems' hydrogen-from-water separators are used on all Shuttle Orbiter flights. These devices remove excess hydrogen from the water produced as a by-product of the Shuttle's electricity-generating fuel cells. The treated water is used for drinking by the astronauts.

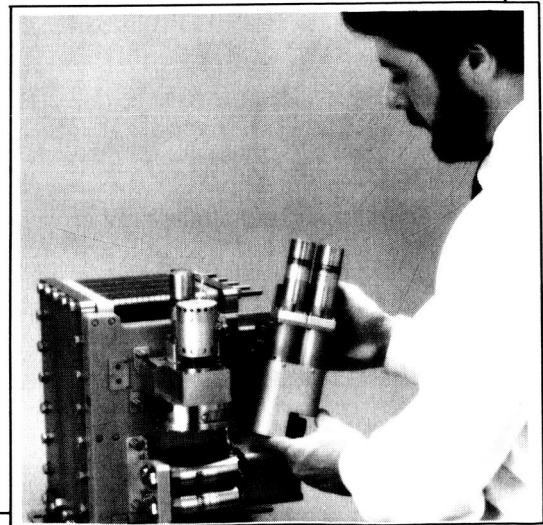
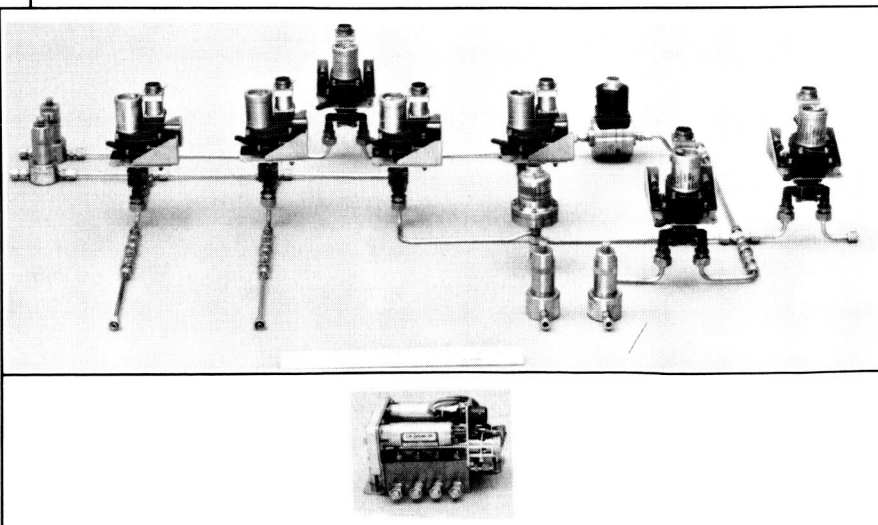
Life Systems understands that an obligation of being in business is to efficiently produce products that meet the quality needs of its customers. Since its founding the company has operated with the idea of being a quality- and productivity-conscious organization. Based on this philosophy, the company has continually sought ways to improve the quality of its products and increase the productivity of its staff.

Life Systems has always attempted to operate in the spirit of NASA's productivity and quality improvement programs. The company has embraced the Productivity Improvement and Quality Enhancement (PIQE) program as a continuation of these efforts. One major advantage of this program is that it provides an excellent opportunity to structure our quality and productivity improvement activities within a coordinated program that covers a broad range of technical, production, and administrative activities.

Life Systems designed its PIQE program around its particular needs. The company

Before and after: Reducing product complexity increases productivity for producer and user.

Static Feed Electrolyzer: Designed for easy maintenance by crew members.



has attempted to structure its program in a way that better assures that program goals and objectives are met and that they can be successfully managed long term. There are four key elements to this structure.

- First, all functional areas within the company are part of the PIQE process, since all areas affect the company's ability to become a quality- and productivity-conscious organization, and all areas contribute to the quality of the company's products and services.

- Second, productivity and quality improvement activities are organized within discrete projects, managed the way any other projects would be managed: their tasks are budgeted and scheduled, their progress is monitored, and they have stated objectives and deliverables, which are often new or upgraded systems or procedures that then become a standard part of company operations. This type of project organization also helps the company respond faster to changing priorities and to maintain the flexibility needed to address the most critical quality and/or productivity concerns first.

- Third, individuals within management are given specific responsibility for coordinating the various technical and administrative PIQE projects under way at any given time. This helps assure diverse efforts are better coordinated for the most efficient use of scarce resources and that top management is kept informed of PIQE program status. The PIQE program coordinators are also responsible for evaluating the company's progress with productivity and quality improvements, and bringing to the attention of top management additional needs or opportunities in these areas.

- Fourth, the description and functioning of the company's PIQE program are detailed in a formal program plan, similar to the plans written for the company's contract programs. Among other things, the plan defines PIQE program responsibilities and the requirements for individual project management and program reporting.

The program is also dependent upon a work environment that is conducive to achieving productivity and quality improvements. The foundation of Life Systems' PIQE program is such an

environment. It starts with attracting dedicated, capable people who are willing to strive to meet the high quality and productivity expectations of the company.

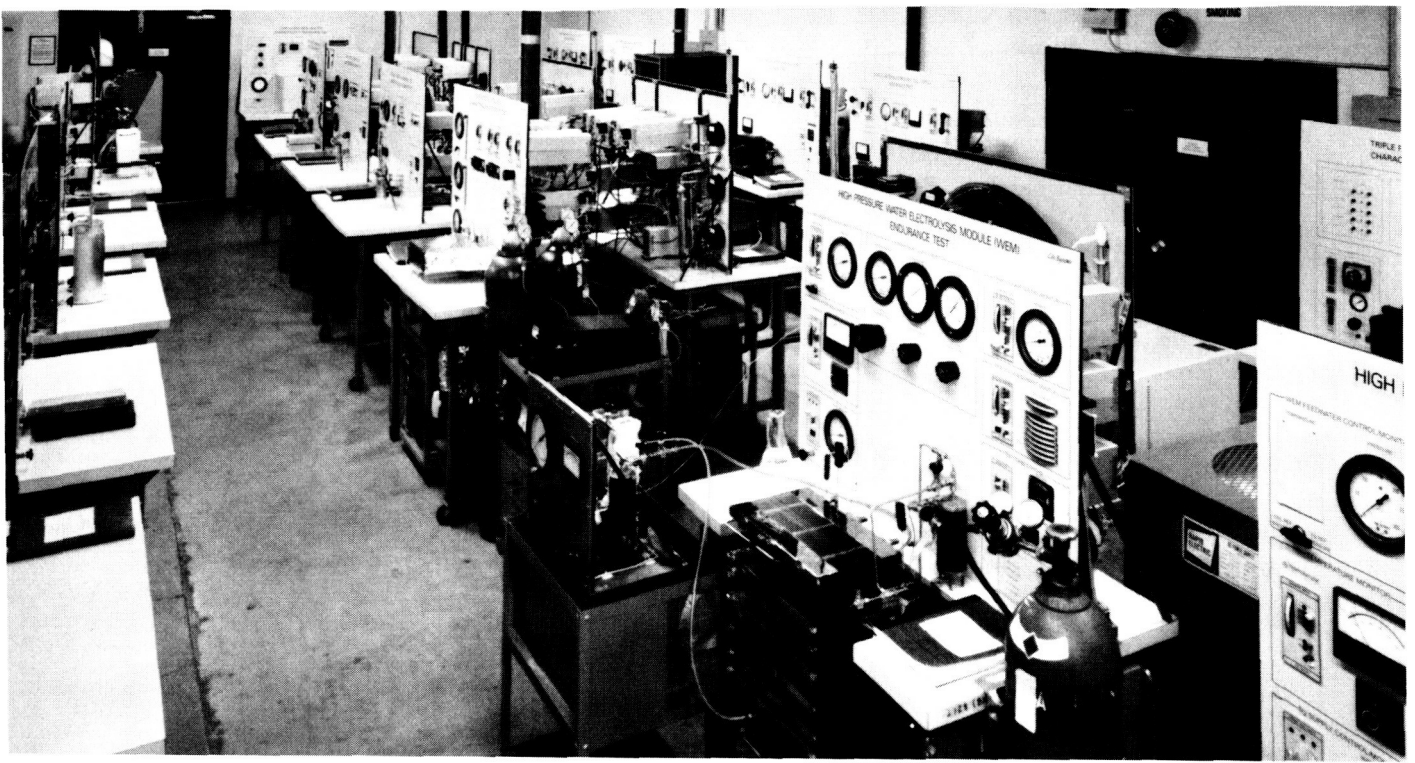
But the real challenge comes after employment begins. We recognize that nurturing the proper attitude and developing skills and competencies must precede formal systems if the desired results are to be realized. An organization fulfills its potential to the degree it enables its employees to fulfill their potential. Life Systems recognizes the value of employee training and development and has several programs to meet that need, from tuition reimbursement to professional memberships, from seminar attendance to in-house training.

For example, in 1985 over 25 percent of the employees took courses, participated in seminars, or attended professional conferences paid for by the company. Equally important, Life Systems advances people within the organization and provides on-the-job training to accomplish this. People are not limited by their current position, but are encouraged to become what their talents and desires will allow.

Life Systems also attempts to create an environment where professional respect and awards are given to individuals who achieve the company's high standards of performance. As part of this the company continues to develop and improve its various reward and award systems, and to tie them more directly and immediately to people's performance and their recognized contribution to quality and productivity improvements. In 1985, for example, half of our employees were awarded bonuses for superior performance, in total amounting to 5 percent of the company's payroll.

A proper work environment also provides methods for employees to communicate their suggestions for improving the organization. Life Systems has designed a Quality Work Group program to tap the collective expertise and experience of its employees in addressing quality and productivity concerns. But we also use other methods to foster a team spirit and improve the company's quality and productivity.

For example, the company has formed broad-based teams of employees, involved in common technology areas, who meet regularly to discuss quality and other



Endurance testing results in extended product life for components and systems.

concerns. Productivity and quality have improved because of shared information: lessons learned on one program do not have to be relearned on other programs. Many department meetings are also structured to encourage two-way communication so improvements or problem solutions can be arrived at collectively.

The most effective quality control is to minimize defects by addressing actual and potential quality problems early in a product's development. Life Systems has several product design enhancement systems to improve the quality of its products at the design stage, including:

- **Computerized Process Simulation.** Using PCs and our own software, we are able to simulate normal and abnormal operating conditions to perform some component and systems testing without putting the actual hardware at risk. Identified problems are then corrected early in the design stage, saving development time and money.

- **CAD/CAE.** Although a major investment for a small company, use of computer-aided design and computer-aided engineering not only helps improve product

quality during design stages, but also significantly improves productivity. Designs are created and stored in layered subsets so in the future applicable design sections can be retrieved rather than redone. Also, various design analyses are able to be performed during the conceptual stage, greatly reducing design problems at later stages.

- **Component Characterization and Endurance Testing.** This expansive program has enabled the company to noticeably extend the life of many components and subassemblies. For example, based on over 35,000 test hours on baseline static feed electrolysis hardware and over 20,000 test hours on electrochemical CO₂ removal hardware, the projected lives of their components are now over 100,000 hours. Data from such testing has proved invaluable in identifying necessary design changes. Over 30 test systems have been put into service, with many delivered to customers.

Work scheduling enables a company's resources to be allocated and used more productively. High quality work is produced consistently and efficiently when it is properly planned. Life Systems uses

various work measurement systems to monitor progress and provide employees with timely feedback on their performance, based on the premise that good employees tend to want to know what their objectives are and how they are performing relative to them. Among these systems are the following:

- Program Status Analysis. Computer-generated reports provide overall and task-level schedule and budget status for each active contract program. These reports form the basis of monthly reviews between program managers and upper management. This system has proved to be very useful for the early identification and correction of scheduling and cost problems.

- Technical Service Requests. This has proved to be an effective method of authorizing and scheduling technical assignments and monitoring their progress. This is a particularly difficult task with development work because unforeseen problems can arise that may make original task estimates almost meaningless. This system is also used to identify over- or under-capacity conditions in time for appropriate adjustments to be made.

- Word Processing Center (WPC) Work Measurement System. Because of the large and often complex requirements for technical reports, studies, proposals, and other documents, WPC is in reality a major production and assembly department for many of the company's deliverable products. This system measures department throughput and capacity, as well as individual and department productivity, and has been helpful in identifying workflow problems that were subsequently corrected.

Life Systems considers its subcontractors and vendors as extensions of itself and uses them similar to the way large companies use their functional departments or divisions. The company expects the same conscientiousness about quality of products and services from them as it expects from its own employees. We work closely with our subcontractors to make them a part of our team and to help them meet our common goals of high quality and productivity.

We have several systems in place to communicate our quality requirements to

them and to evaluate their capabilities and performance before, during, and after doing work for us.

One method is a subcontractor rating and selection process that uses questionnaires, on-site visits, and evaluations of past performance to identify those companies eligible for our Preferred Vendor List.

A second method is to provide our subcontractors with formal guidelines which present our philosophy on quality and which outline subcontractor quality assurance requirements. Where applicable we also hold preliminary meetings with subcontractors to review drawings and other pertinent data that will help them more fully understand the requirements of the job. On-site inspections of work in process further help us to work closely with our subcontractors to expeditiously identify and resolve quality or schedule problems.

Life Systems appreciates the value of its human resources and consciously attempts to provide the modern tools necessary to make the best use of its talented people. This commitment is demonstrated in all areas of the company, from the use of CAD/CAE and computer simulation for increased product quality and productivity in the design process, to a fully automated word processing department and a communications network linking PCs, word processors, an Optical Character Reader (OCR), and automated typesetting equipment. For example, the company averages one PC or word processor for each three employees. Also, all managers and professional employees are provided with dictation equipment, use of which saves considerable time for the document originator and the typist.

There are, of course, many other elements to our PIQE program, which is constantly evolving. One of the values of our PIQE program, in fact, is that it helps us to structure our efforts into an effective and broad program, and to incorporate new methods that will enable us to progress even further with productivity and quality improvements in the future. We are committed to continued progress in meeting the spirit and fulfilling the goals of the PIQE program. □

Martin Marietta Michoud Aerospace

Commitment to Excellence

Developing and improving productivity while maintaining high quality is standard business practice at Martin Marietta. We simply have to be—and I believe there is significant evidence that we are—committed to working productively every day. We have an ethical obligation and a social responsibility to produce products of the highest quality at prices our customers can afford, and our commitment is an integral part of discharging that responsibility.

We have worked diligently to develop a “mission success” culture at every level of our organization. The Space Shuttle external tank project is an excellent example that our efforts are producing results.

Our record of building and delivering tanks of the highest quality, on schedule, while at the same time increasing production rates and reducing both costs and nonconformities, speaks for itself.

Thomas G. Pownall
Chairman and Chief
Executive Officer
Martin Marietta Corporation

Martin Marietta is a high technology company engaged in the design, manufacture, and integration of systems and products in aerospace, defense, electronics, information and data management, energy, air traffic control, and materials. We are a people-oriented company of 66,000 employees located in 41 states and 9 countries.

Our rich resources of motivated, talented, high technology people are developing and producing a wide range of products and services. For example, scientists at the Martin Marietta Laboratories have developed a new family of metal matrix composites that promise to improve performance, reduce costs, and simplify production of space structures.

Martin Marietta's diverse space programs include the Space Shuttle external tank and other Shuttle elements and services, the Manned Maneuvering Unit (MMU), design of habitable Space Station modules, and a Venus Radar Mapper spacecraft.

Martin Marietta is in the forefront of the rapidly emerging technology for information management systems that combine software, hardware, data links, and the technologies for man/machine interface.

Since 1979 our IR&D effort has resulted in external tank (ET) technical directives and study contracts for NASA and the DoD in excess of \$38 million. These programs include ET applications, Shuttle derived vehicles, aft cargo carrier, Shuttle processing, STS propellant utilization, Space Station, and orbital transfer vehicle. During 1985 our IR&D projects included welding automation, nondestructive evaluation of nonmetallic materials, analysis of polymer materials, composites at temperature extremes, electrostatic cooling, robotic process development, and residual stress analysis. All of the IR&D projects have either a primary focus or provide specific technical benefit to NASA and the external tank program.

An outstanding feature which demonstrates the inherent Productivity Improvement and Quality Enhancement (PIQE) philosophy

developed within our organization was the achievement of a 68 percent production improvement curve during the early phase of production, when an 84 percent improvement curve was deemed extremely optimistic. Even more dramatic was that this 68 percent improvement was accomplished during major facility and factory rearrangements.

With the completion of 1,989 tool projects, system redundancy has been added to the manufacturing process. This has reduced the number of dolly moves from 310 to only 32 per ET. The facility is now in position to reach production rates of 20 ETs per year and can achieve a capability exceeding 24 ETs per year if and when required by NASA.

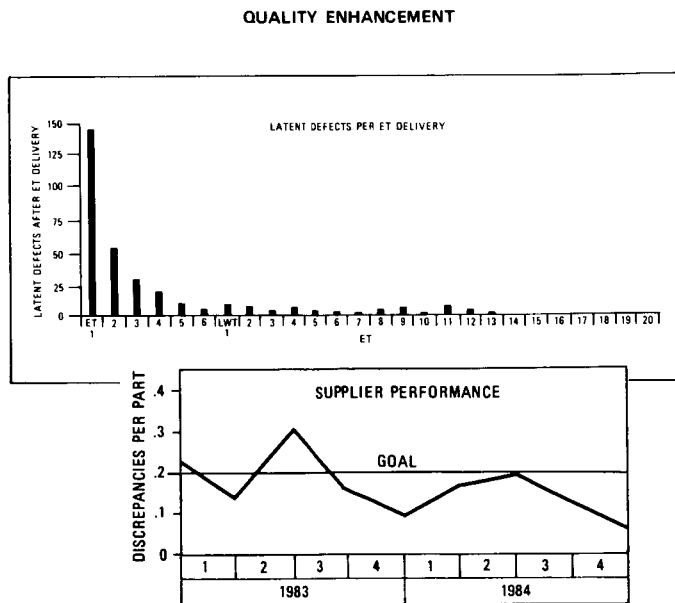
The factory flow for the external tank is a complex and sophisticated process, and the identification of the most efficient approach required use of computerized dynamic simulation. As a result, line balance was achieved throughout the process, eliminating the need to add major tools by carefully redistributing the work on existing tools or adding simple offload tools. For example, analysis and modification to two major welding lathes avoided the additional expenditure of \$30 million.

The organization evolved from a pure line functional structure into one with participative management concept and with multitalented specialist teams to identify and solve problems. To aid these teams in obtaining information for a particular problem solution, our entire engineering data base is being converted to computer-aided three-dimensional models. In addition, this pioneering work established a CAD design model which not only benefits the Space Shuttle program, but can also be applied to the Space Station project to achieve life-cycle cost goals.

The factory automation increased visibility of critical performance measures and decreased the reporting turnaround time. Therefore, we automated our catalog of more than 30,000 engineering drawings and correspondence. This significantly improved the availability of data and reduced the turnaround time for drawing and correspondence requests.

Another major computer system is our MOTION system which provides real-time data on work in process throughout the

Figure 1



factory, as well as labor accounting, with labor performance based on work standards. These data are provided through transactions on the factory floor accomplished by each employee. In addition, we expanded this to the "white collar" areas of computer programming, CAD engineering, and production planning.

Other PIQE initiatives include the tool-status accounting system which provides current information on 15,000 tools, including the relation of the tool configuration of the external tank. This system tracks the production of new tools as well as the maintenance and certification of existing tools.

Our production-control data-reporting computer system provides production control personnel real-time status on work in process and provides rapid response information on any variances. We have also developed a functional cost management computer system which automates the accounting of touch labor. One result of this was a reassignment of some staff to more productive output while increasing data quality required for factory cost control.

Furthermore, the development and implementation of bar coding for small

and calibrated tool inventory cribs has resulted in more reliable identification and reduced manpower and material requirements. Additional bar code applications are being developed and implemented for inventory control as well as to enhance the MOTION system.

This continued modernization of facilities and equipment has been reflected in the activation of a new facility used to process an ablative insulation material and the development and implementation of a new plasma arc-welding torch for use in production. Activation and operation of the new component ablator facility has reduced ablator waste by 67 percent.

The activation of the joint NASA/Martin Marietta plasma arc-welding (VPPA) process on the ET barrel, T-ring, and aft ogive trim and weld fixtures has resulted in a 90 percent reduction in weld defects when compared to the previous tungsten-inert gas welding process. A new ET dome body trim and weld fixture will provide a more reliable and accurate rate production station for the ET dome segments. Similar savings are being derived from the self-cleaning aspect of the plasma arc-welding process.

We took another innovative approach to identify specific areas that required technology transfer in order to bring the manufacturing process into usable state-of-the-art technology.

One example has been the development of a unique cost-saving molding process for the ET's thermal protection system. This process was transferred from the university research laboratory to production in less than one year. This innovation eliminated expensive machining, reduced the manufacturing process time, and significantly reduced waste of "value added" material.

An equally important measure of the success of our PIQE program is the quality of the delivered external tanks. Nonconformances have been significantly reduced (Figure 1) to a level of approximately three latent defects per external tank. This performance level exceeded the ET Project Office's goal of fewer than six latent defects for ten successive delivered external tanks. None of the latent defects has caused launch delays or required a significant launch-site effort to resolve.

In addition, the flight performance of the external tank clearly demonstrates the successful PIQE program at Michoud. We have never had a flight-critical or launch-critical anomaly.

Our quality performance, as measured by the number of hardware discrepancies per ET in work in our major manufacturing area, is shown in Figure 2. The overall manufacturing performance improved by 28 percent.

Planning errors, as represented in the number of errors per page found in the stand-alone Manufacturing Process Plans (MPP), have been reduced by approximately 82 percent.

Engineering errors, as reflected in the number of requests for correction (liaison calls) initiated, have declined by 38 percent. As part of our PIQE effort, we introduced a Productivity Action Call (PAC) system which provides a method for identifying and implementing nonmandatory changes that improved the productivity and quality of our production operations. This system has yielded cost savings of more than \$100,000 per ET in one year alone.

Nonconforming hardware dispositions (rework, repair, scrap, and use as is), shown in Figure 3, have steadily decreased. In addition, the amount of hardware requiring Material Review Board action decreased at the same time.

The number of Martin Anomaly Reporting System (MARS) document or nonconformance reports per external tank has been improved by over 40 percent

Figure 2

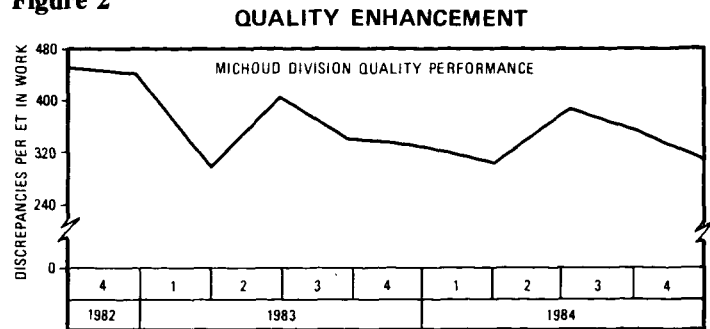
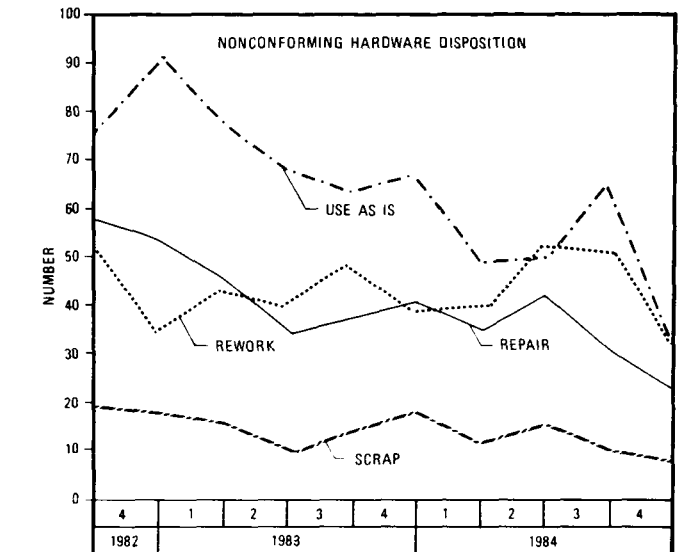
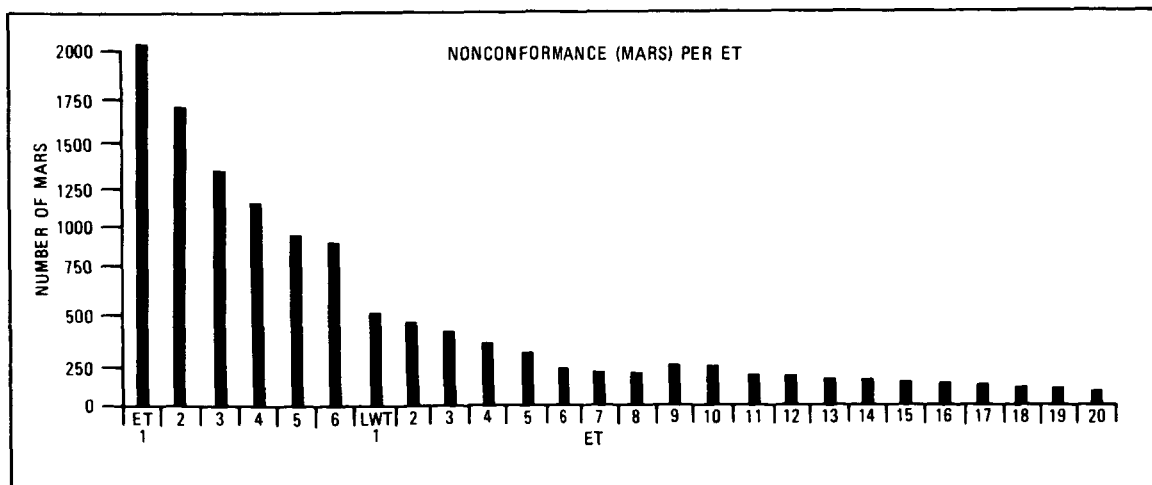


Figure 3



(Figure 4). All of these quality performance improvements have been achieved while the cost of quality assurance has decreased by 27 percent.

Figure 4



As a part of this effort, a goal-oriented computerized quality performance trend system was brought on-line to enhance the existing manual system. Monthly reviews with the responsible area managers are conducted to discuss trend data relative to established goals, identify cause and actions for correcting adverse trends, and assess the effectiveness of past actions. In addition to disseminating this information to Martin Marietta's senior management, DCAS, and NASA, performance trend charts are displayed in key locations throughout the factory.

Since a significant portion of the ET cost is associated with procured hardware, we apply the same statistical measurements for our major hardware suppliers. For example, from the fourth quarter of 1982 through the fourth quarter of 1984, we achieved a 74 percent reduction in the number of discrepancies per part for major hardware delivered. We achieved this through an aggressive source surveillance system and immediate implementation of effective corrective action.

None of the above approaches to PIQE would be successful without our positive and committed employee attitudes. This has been clearly demonstrated in the response to our 1984-1985 employee survey. It was the consensus that PIQE is a part of every employee's consciousness, and it further reconfirmed our commitment:

	Favorable
To Mission Success	99%
To our NASA Customer	98%
To providing a high quality product and service	97%

We have learned lessons from our PIQE program which have prompted the following 15 recommendations to be followed to assure continued success:

- 1) Management must be dedicated to PIQE from inception to completion and PIQE must be permanently integrated with management philosophy and strategic planning.
- 2) Make your customer part of the PIQE effort.
- 3) Disseminate PIQE objectives to all employees.
- 4) Communicate—and hear. We sometimes listen but do not hear.
- 5) Set realistic, achievable goals. High

achievers rise to the challenge.

6) PIQE works best when each department or function group works it down to the lowest level when identifying opportunities for improvement.

7) Communicate and coordinate PIQE across departments, so that a cost reduction in one department does not come at the expense of another.

8) PIQE indoctrination and training is important on all levels, but is most important for executive management.

9) The best chance for PIQE success is when the individual responsible for the improvement is also responsible for carrying it out.

10) Do not restrict PIQE measurements to human resources; include all resources.

11) Establish and maintain a reward system for successful implementation of PIQE candidates.

12) Use the subcontractor's systems wherever possible. Do not implement your system when his system is reasonable.

13) Communicate early (in the bidding phase) with the subcontractor your management's commitment to productivity and quality; commit his top management to a productivity improvement program; and continue the program with a productivity committee, progress reports, and face-to-face action.

14) Control procured hardware by contract and quality flow-down to second- and third-tier suppliers.

15) Be generous with help where subcontractors lack depth.

Through the diligent and continuing application of PIQE processes we have generated cost savings of greater than \$1 billion while delivering every ET on or ahead of schedule and reducing our nonconformances 76 percent in three years. Our PIQE process is continuous and iterative. It encompasses all functions that contribute to the manufacturing, delivery, and support of the external tank. It includes a formalized goal-setting system that communicates division goals to the individual contractors. Advanced management techniques are used to plan, track, and measure performance. Our management has created and is sustaining a climate that makes PIQE every employee's business in achieving the goals of improving the "quality of work life," reducing ET production costs, and improving product quality. □

McDonnell Douglas Corporation

McDonnell Douglas Astronautics Company—Huntington Beach

The Integration, Organization, and Success of Numerous Participative Management Programs

As Chairman and Chief Executive Officer of the McDonnell Douglas Corporation, I am concerned about the worldwide market condition we face as a nation and its impact on our organizations. In response, I have established a process of continuous improvement that I call the Five Keys to Self-Renewal. Quality and productivity are at the core of this process, and it is my personal goal that all of our employees, and all of our suppliers, are committed to this philosophy. I applaud NASA for emphasizing quality and productivity, and I believe that if we work together, as a team, it will help us both to achieve our goals and reassert our nation as a leader in quality products and systems.

Sandy McDonnell
Chairman and Chief
Executive Officer
McDonnell Douglas Corporation

McDonnell Douglas Astronautics Company—Huntington Beach has always been deeply concerned about the quality and integrity of the products we supply to the National Aeronautics and Space Administration. We are now actively involved in implementing the Five Keys to Self-Renewal into procedures, systems, and philosophies that promote quality and productivity through continuous improvement. We take a great deal of pride in the knowledge that the involvement of our employees in the decision-making process has resulted in significant accomplishments in quality and productivity. MDAC-HB is clearly a company of quality people and quality products.

C. James Dorrenbacher
Vice President—General Manager
McDonnell Douglas Astronautics
Company—Huntington Beach

The McDonnell Douglas Astronautics Company in Huntington Beach, California, (MDAC-HB) is located on a 250-acre site about 30 miles south of Los Angeles. The facility is dedicated to providing high-quality space, missile, and communications, command, control and intelligence systems that are within budget and on schedule.

A major focus of this division has been to help pursue the goals of the National Aeronautics and Space Administration. In the 1950s, MDAC-HB developed the nation's first intermediate range ballistic missile—the Thor. Thor became NASA's three-stage Delta rocket in the early 1960s. Known as the "workhorse" rocket, Delta has put more than 170 satellites into orbit in over 25 years with an unequaled success rate of 94 percent.

MDAC-HB was also selected by NASA as a major contractor on the Apollo program, delivering the second stage of the Saturn IB and the third stage of the Saturn

V rockets. In the early 1970s, the company helped NASA provide America's first manned space station—Skylab.

MDAC-HB has continued its service to NASA and the nation through its involvement in the Space Shuttle and Spacelab programs, as well as in the commercial Payload Assist Module and advanced technology research. MDAC-HB is currently doing the preliminary designs for NASA's Space Station and looks forward to being involved in the final design, production, and completion of NASA's goal of a permanently orbiting space station.

Improving productivity and enhancing quality have long been a way of life for the employees of McDonnell Douglas Astronautics Company—Huntington Beach, and tangible evidence is provided in the success of the Delta program. The Delta space vehicle has performed all 43 of its missions flawlessly over the last 7 years.

Our incorporation of NASA's PIQE program is documented in our Management Improvement Program (MIP) plan. The thrust of the plan is self-renewal. Our ultimate goal is to change the way we do things by developing a company culture that will maximize productivity to benefit not only the corporation but also the individual. Productivity improvement as a long-term strategy is emphasized by McDonnell's Chairman and Chief Executive Officer, Sandy McDonnell, in his five initiatives: Five Keys to Self-Renewal.

1) Strategic Management. Knowing where we want to go and deciding what we need to get there.

2) Human Resource Management. Making use of every available opportunity to help individuals develop their full potential.

3) Participative Management. Giving every employee a full opportunity to participate in shaping the future of the corporation.

4) Quality/Productivity. "Doing it right the first time."

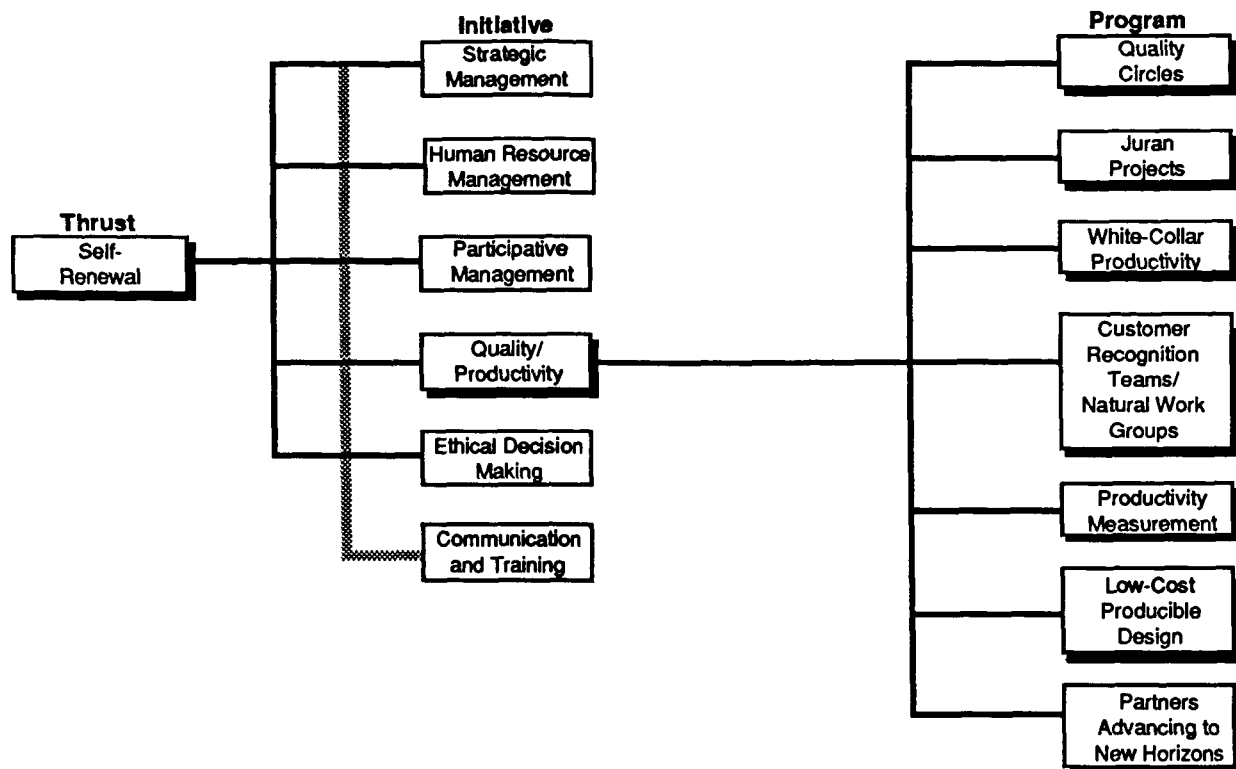
5) Ethical Decision-Making. Setting high ethical standards for all elements of MDAC-HB and making difficult decisions without compromising those standards.

Cornerstones of the MIP are quality circles, Juran projects, white-collar productivity improvement, and customer



WE ARE . . .
Institutionalizing the self-renewal process to involve all personnel at all levels so that they may have a stake in the decision-making process

Figure 1. Management Improvement Program Plan



recognition teams/natural work groups. Figure 1 depicts the relationship between the thrust (self-renewal), the initiatives (strategic management, human resource management, participative management, quality/productivity improvement, ethical decision-making, and communication and training), and the programs.

Our quality circles, made up of employee volunteers, meet regularly to identify, analyze, and assist in solving problems, which results in increased productivity. Participants receive an overview of the program and training in problem solving. Circle members are recognized and rewarded with sweaters, lapel pins, trips to Delta launches and Shuttle landings, an annual recognition banquet, and an overall sense of satisfaction.

Juran's methods for improving quality and productivity through an institutionalized program of annual improvement are also widely practiced at MDAC-HB. Extensive training takes place and teams are assigned to organize, diagnose, and find remedies for system concerns.

At MDAC-HB we emphasize the necessity of integrating productivity

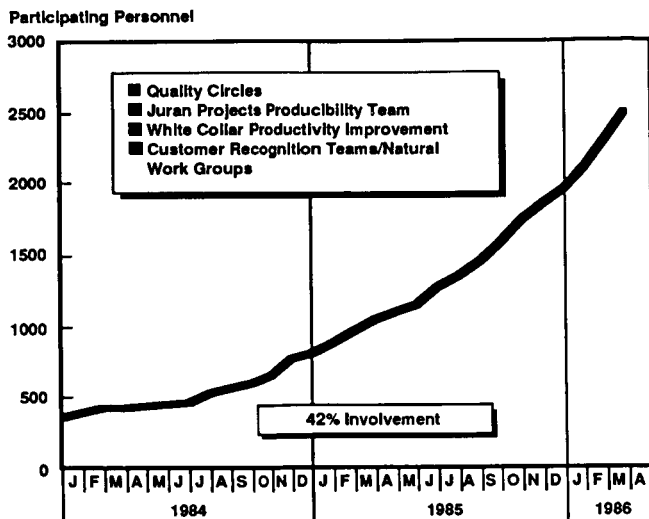
disciplines into all functional departments. Projects have been undertaken within Engineering and Operations, Business Management, Human Resources, Product Assurance and Logistic Support, and the Strategic Business Units. The results of the various projects are reported to all levels of management by a formal management presentation. Accomplishments and implemented changes are documented, and items requiring management action are assigned to the appropriate managers to accomplish the task or to provide status feedback.

MDAC-HB has participated in an action-research White-Collar Productivity Improvement Program supported by the American Productivity Center (APC) of Houston, Texas. Pilot projects have been initiated, the objectives of which are (1) to develop criteria for improving managerial and professional effectiveness, and (2) to develop and refine methods of and approaches to improving white-collar productivity.

APC teaches an approach to achieving strategic objectives that is the basis for (1) improving capital utilization and return on new information resource management

Figure 2

MDAC-HB Commitment to the Renewal Process



technology, and (2) aligning human resources to new department objectives and work redesign. At MDAC-HB, for example, we have aligned the efficiency objectives of the quality circles and Juran project teams (with the "do it right the first time" philosophy) to the effectiveness objectives of the white-collar productivity improvement (WCPI) projects ("doing the right thing"). Our guide is APC's six-step approach: diagnostics, objectives, measurements, design or redesign of services, team-building, and technology parameters.

Customer recognition teams/natural work groups (CRT/NWG) are composed of groups of employees who are in the same work group. Meetings are held for 1 hour weekly to bring forward problems and ideas oriented toward making jobs more productive and improving the quality of work life. The basic philosophy behind CRT/NWGs is common destiny—sharing power and privilege. This will be accomplished by the group initially surfacing current problems for correction and eventually becoming the participative group that will manage the activities in that particular area.

The key word is "customer." We recognize that we all have a customer for our efforts, and that only by satisfying those customers can we gauge the success of our efforts. Our customers are, first of all, the recipients of our products who, after all,

pay the bills; second, and most important, our employees and their degree of personal satisfaction; third, the top management team whose policies we execute; and last, but not least, the stockholders to whom we owe a reasonable rate of return and ethical conduct.

In turn, each CRT/NWG has a set of customers who are the recipients of their efforts, and they, in turn, are supplied by a set of suppliers, both internal and external. This process holds true whether the output is paperwork, fiscal reports, software, or hardware. Once in place and with the proper training, MDAC-HB CRT/NWGs better understand their supplier and customer needs and how to best meet those needs. They will then be able to assume a greater share of the management responsibility with greater autonomy and authority, with the end objective being to "do it right the first time."

To assist the CRT members in resolving issues and doing their work more effectively and efficiently, a "bias-for-action" network has been established. This network includes a computerized action item tracking system, support groups, and a bias-for-action manager. All action items surfaced by the teams are entered into the computerized system and are tracked to closure. Responsibility for action is assigned to the appropriate support group. The bias-for-action manager is responsible for ensuring that appropriate action is taken at all levels and in every organization in a timely manner. The system has the definition, top management support, and closed-loop feedback necessary to assure the CRT members that they will be heard.

To provide management with an indicator of our progress in instituting the culture change and to encourage further involvement, the percentage of the work force participating in the various activities is being tracked (Figure 2). The members of these program activities are not only trained into the new concepts, but have committed to incorporate the thinking into their daily routines.

Over the years MDAC-HB has often worked closely with individual suppliers to meet special programmatic technical needs, schedules, etc. Productivity improvement and quality enhancement processes used at MDAC-HB

are communicated to all of our critical suppliers who do not have programs of their own. In November of 1980 MDAC conducted a quality symposium for the suppliers of major and critical hardware to the Delta program. Today, we are formalizing a broad program of supplier quality and productivity improvement. MDAC, along with several other MDC components, has adopted the acronym PATH (partners advancing to new horizons) as the descriptive title for this ambitious program.

The PATH initiative acknowledges that the quality and cost of our finished products depend on the quality and cost of the parts—many of them purchased parts. PATH enlists the support of our suppliers for continued progress by encompassing:

- Supplier communication. We will have communication with suppliers, including group conferences and one-on-one visits.
- Quality evaluation. We are aggressively pursuing improved methods to measure objectively the quality performance of our suppliers. In addition, we are conducting quality assessments to assist in identifying areas for improvement. Quality ratings will continue to be used in source selection.
- Performance evaluation. On-time delivery is just as essential as quality to our goal of improved productivity. MDAC is reducing work-in-process and inventory levels, making late deliveries intolerable. In addition to applying quality ratings, we review the delivery history of suppliers during the source selection process to give consideration to those suppliers with a history of reliable performance.
- Consultation on productivity and quality. Sharing our years of experience, providing training materials, and instructing suppliers promotes a quality product. Suppliers, in turn, provide ideas from which we learn.
- Lead-time improvement. Reducing build-cycle time is a key goal. We recognize those suppliers who show significant lead-time reduction and investigate alternatives to speed delivery of major and critical commodities.
- Recognition for excellent suppliers. We appreciate the support and dedication of suppliers through the years, and we plan to publicly recognize them and reward their outstanding performance.

We have structured PATH to make us all

winners. Our suppliers win by becoming more competitive, by winning new programs, and by maintaining or increasing their business. MDAC wins by maintaining and improving its position as a leader in the aerospace industry. Our customers win because the best possible products will be available, affordable, and of superior quality.

Our indicators furnish measurable evidence that our productivity improvement and quality enhancement processes are working. Rejections per 1000 manufacturing hours (for all programs at MDAC-HB) were reduced from 7.7 to 3.0 from the first quarter of 1983 through the last quarter of 1985. This is a reduction of 61 percent. Turnover and shipping records show that for the past 5 years the Delta launch vehicles have been delivered with no shortages.

Additional examples of quality and productivity improvements that have resulted in a demonstrated savings of \$15,000,000 in the past 3 years are as follows:

- Software data files—yearly cost savings of \$160,000.
- Financial controls—33 percent productivity gain.
- PAM drawing system—improved productivity by 40 percent.
- % Accounts receivable—\$323,000 total realized and anticipated 1985 savings.
- DC/KC/10 pylon assembly—\$850,000 savings CY84/CY85.
- Parts handling and protection—\$1.1 million per year reduced to \$20,000.
- F-18 production—\$8,500,000 savings FY82 through FY84.

The Delta program is just one example of customer satisfaction with the products and services of MDAC-HB. During its 25-year history, the Delta launch vehicle has compiled an impressive record of successful launches from both the eastern and western launch sites, orbiting 166 satellites of 177 attempts, for an overall reliability of 93.8 percent since the first Delta launch in 1960.

MDAC-HB intends to continue to provide high-quality performance, on-schedule delivery, and stringent cost control, making MDAC-HB an even more successful company and NASA an even more satisfied customer. □

United Technologies

Pratt & Whitney
Government Products Division

A Suggestion System and Cost Reduction Program

To continue to succeed, Pratt & Whitney is committed to excellence in all that it does. Pratt & Whitney will continue to ensure it receives maximum benefit from its available resources, and it will continue to search for new, innovative methods and technologies to improve its products and its operations. At Pratt & Whitney we recognize that leadership is not something given—it has to be earned: earned at the design boards, on the component rigs, in the test cells, on the wing; earned in service, day after day, year after year. We know, too, that with leadership comes responsibility for inventiveness and purpose. It's a commitment to excellence that we at Pratt & Whitney do not take lightly, and it's reflected proudly in our products.

James G. O'Connor
President, Government Products
Division
Pratt & Whitney

Like its parent company, United Technologies Corporation, Pratt & Whitney is active on a global scale, competing with the most technologically advanced companies in the leading industrial nations of the world.

Pratt & Whitney has become the world's leading designer and builder of high-technology aircraft power plants and rocket engines as a result of its innovative, pioneering spirit. Since its founding in Hartford, Connecticut, more than 60 years ago, Pratt & Whitney has produced high-performance engines for more than 1200 different types of aircraft—from the biplanes of the 1920s to the swept-wing, supersonic jets and the upper-stage rocket engines of NASA's space exploration fleet of the 1980s.

In 1976 Pratt & Whitney was reorganized, and the Florida facility became the company's Government Products Division, with responsibility for all military gas turbine programs as well as liquid-fuel rocket engine programs. In 1983 the company organized its government products and commercial products engineering teams into a single division in order to improve use of existing resources and to allow the company's commercial and government customers to benefit from each other's experience. The Government Products Division has responsibility for managing all government engine programs and coordinating engineering requirements with the Engineering Division staff in Florida.

Today, Pratt & Whitney's engines power nearly 5000 U.S. jet aircraft, nearly half of the fixed-wing fleet. Pratt & Whitney rocket engines also serve as the upper-stage workhorse of NASA's space exploration fleet, launching an array of unmanned spacecraft on earth orbit and interplanetary missions.

Pratt & Whitney's government programs team continues their tradition of excellence, pushing beyond the established frontiers of technology in a continuing quest for superior products.

One of the key programs used by Pratt & Whitney to improve operations, involve employees in decision-making, and save money for customers is the Cost Reduction Program at the company's Florida facility.

Pratt & Whitney has operated a cost reduction program since 1964. The system introduced at that time was established in direct response to a memorandum issued by the Department of Defense (DoD) to its prime and subcontractors operating under defense contracts.

In first requiring cost reduction programs, the DoD specified that a program must meet a number of criteria. It must be sponsored by top management, emphasize cost reduction throughout the organization, establish specific goals or objectives, measure and report cost reductions accomplished, motivate employee participation, and promote the interchange of ideas throughout the contractor's organization.

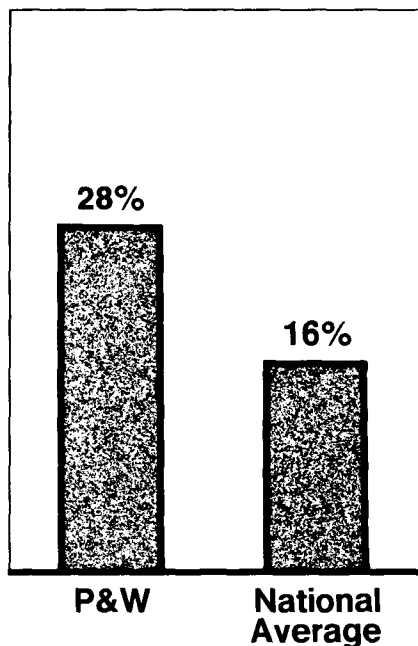
The DoD defined cost reduction as decreasing the total cost, individually or collectively, of material, labor, or overhead through improved management, techniques, procedures, or processes when compared with previous operations and methods without sacrifice of requisite quality and reliability. DoD particularly encourages cost reduction actions which result in reduction, elimination, or avoidance of expenditures of funds which, had they been incurred, would have been recognized as allowable costs and reimbursed by the Department of Defense. The criteria in the original DoD memorandum were, and still are, prominent features in the Government Products Division's Cost Reduction Program.

Pratt & Whitney has the following criteria for cost reductions:

The change must result in reduction, elimination, or avoidance of a previously committed or established cost, under similar conditions. A cost avoidance does not constitute a reportable cost reduction, but the avoidance of a previously committed cost under similar conditions does. For instance, the initial choice of a less costly alternative doesn't qualify as a valid cost reduction; whereas, a change from a firmly established and documented course of action does qualify.

Figure 1

Employee participation



It must result from a deliberate and identifiable action by management or an individual employee and can't be the result of uncontrolled, even though beneficial, circumstances.

The savings must be reasonable and measurable in dollars.

The change must become effective, or substantially so, in the current six-month reporting period.

Other reporting requirements specify that a cost-reducing transaction can be reported only once for a maximum effectivity of one year, even though the benefits can be extended for an almost indefinite period of time. Also, labor-saving improvements can only reflect the base labor rate plus fringe benefits for salaried personnel, and only variable overhead can be applied to direct-charging hourly personnel.

The success of the program is completely dependent upon the voluntary contribution of cost-cutting ideas from the entire work force. Government Products Division employees participate in the program at nearly twice the rate of the national average: 28 percent compared with 16

percent (Figure 1). This level of personal enthusiasm is realized through a highly effective merchandise award plan with heavy emphasis on executive management recognition.

The award plan offers points in direct proportion to the approved net dollars saved. These points are used to redeem merchandise from a large, colorful catalog of brand-name merchandise ranging in value from \$5.45 to \$3729. While all division employees are encouraged to propose cost reduction ideas, only those below executive management level are eligible to receive an award if their ideas are accepted and put into practical use.

The use of merchandise points instead of cash awards was implemented in 1985, based on national statistics which indicated the use of merchandise as an award medium was almost four times as effective as any other incentive, including cash. Since being implemented in March of 1985, the merchandise program's performance has exceeded previous in-house programs by almost 26 percent.

Above and beyond material awards, personal esteem is manifested by a written letter of appreciation from the vice president of the recipient employee's department. The letter and award are usually presented personally by the department head. While the merits of this type of action are esthetic in nature, they have a profoundly positive effect on employee attitude. Pride is an important factor to nurture in the solicitation of voluntary employee participation, and visible appreciation from top management is a catalyst that provides self-confidence and a positive attitude toward the program and company.

The quality of proposals is the most significant factor in establishing a favorable ratio of accepted ideas to those that are rejected. Every idea submitted, good or bad, receives individual attention. Therefore, Pratt & Whitney has made presentations to all employees, explaining the fundamental logic involved in the initiation of a cost-improvement proposal. This employee education effort has resulted in a Government Products

Division acceptance rate of 34.2 percent compared with a national average of 22 percent (Figure 2).

In each of the last six years, the Government Products Division's Cost Reduction Program has been cited by the National Association of Suggestion Systems for having the most savings per employee in the nation. In 1985, for example, the Division's accumulated savings totaled \$93,576,339 from an average population of 8011 employees, or \$11,681 per person on the payroll. The national average for 1984, the last complete year for which figures are available, is a savings of \$1257 per employee (Figure 3).

Without dedicated cooperation in the cost reduction cause by management, nothing would be accomplished. Within the Government Products Division, management's responsiveness to and involvement in the Cost Reduction Program has been outstanding. Management is involved in each cost reduction proposal at several stages, including evaluating possible impact, implementation, and assessment of the final results. To illustrate the effect of this cooperation, processing time from receipt of a proposal to closeout of the final documented accomplishment averages 85 days, which is about 50 percent under the national average.

Management interest and active participation in the Cost Reduction Program are enhanced through a performance objective goal. A total division target is established, and then individual departmental goals are set. Department targets are further distributed down to branch and unit managers. Performance against targets is traced and reported monthly.

A cost reduction or employee suggestion system is essentially an individual input program. That is, most of the suggestions come from individuals. The Government Products Division's Cost Reduction Program has provision for additionally recognizing team-originated cost-saving accomplishments, such as from quality circles. Since it's normally a team function to brainstorm their members for ideas, then to campaign to effect this implementation, the Cost Reduction Program is concerned with the reporting of their achieved savings, where

Figure 2

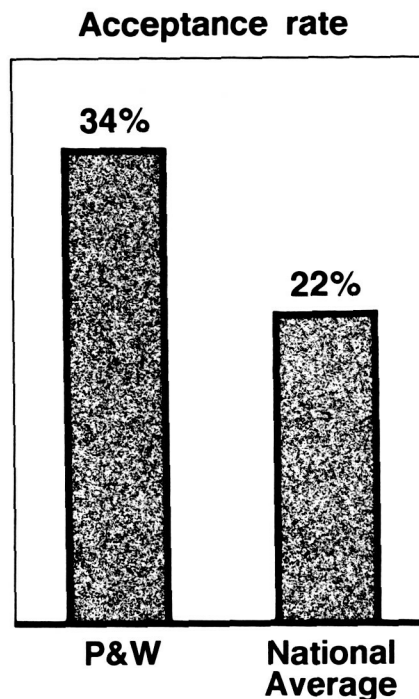


Figure 3

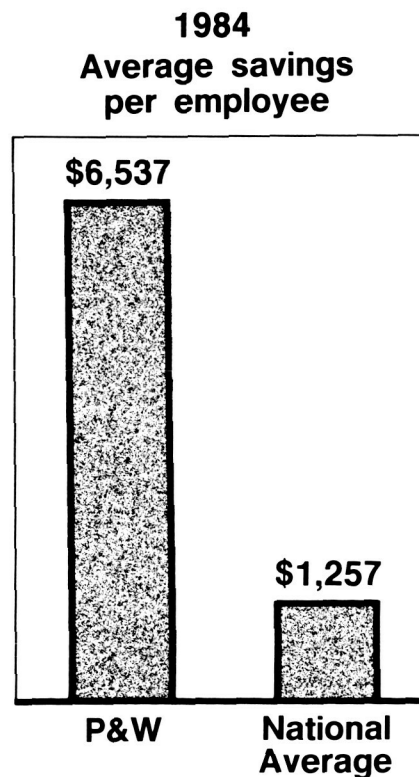


Figure refers to 1984 data; P & W savings per employee climbed to \$11,681 in 1985.

John Buchholz (seated), shown with his manager, Tony Pizzi, is one of several P&W employees who have been recognized by the National Association of Suggestion Systems.



applicable, and the issuance of awards to team members where appropriate. The Cost Reduction Program awards the team as if it were a single individual, equally distributing merchandise points among eligible team members. Team suggestions saved a total of \$1,083,880 in 1985, or 1.16 percent of the total.

There are some negative aspects of a cost reduction program from a company point of view. Some suggestions may save customers money at the expense of a portion of company business. For example, more efficient repair procedures of engine components benefit the customer, but reduce sales of spare parts.

However, Pratt & Whitney is dedicated to remaining one of the industry's lowest-cost producers of high-quality, high-technology products. The Cost Reduction Program involves all employees in the search for more efficient and more economical ways to meet our customers' needs.

Pratt & Whitney recognizes that the

potential of any organization's work force to control unnecessary costs is unlimited. Total efficiency and cost effectiveness are never achieved in any situation, but through an organized and logical system, healthy gains can be achieved. Every employee in every organization, without regard for position, is an expert with unique knowledge and experience that can be tapped to keep related costs to a minimum. Top management must be committed to this premise and must dedicate a full-time staff to administrate a system to encourage the submittal of voluntary proposals from everyone. It takes a responsive system that consistently and dependably rewards innovation to motivate employee participation.

The Government Products Division's Cost Reduction Program provides such a system. Its credibility has been certified repeatedly by various federal audit agencies. This program is an essential countermeasure to the constant upward spiral of costs in the American economy—and it works. □

Reynolds Metals Company

McCook Sheet & Plate Plant

Factory Automation and Participative Management Program

Quality requirements are continually increasing for the materials produced by Reynolds and the aluminum industry. In meeting this challenge, Reynolds, long recognized as the marketing innovator in the aluminum industry, is emphasizing innovation in every facet of its operations. It has been proven that the road to increased productivity and product quality stems from applications of innovative thinking. At Reynolds, new quality assurance procedures have been put in place, and increasingly sophisticated quality programs and procedures are being developed and implemented throughout all of the company's operations.

Research and development have been strengthened and brought into a closer relationship with the company's strategic planning, and many new projects are under way in both process and product development. Reynolds is unique in the aluminum industry in having research and development and quality assurance reporting to a single corporate officer. Through this structure, Reynolds technology and quality operations provide more coordinated research, development, engineering and quality efforts, as well as a special opportunity to impact both quality and productivity.

Innovation comes from a total commitment to quality and to customer satisfaction. It comes from a goal to make the best product every time, on time. It involves striving for continuous improvement in all facets of the company's operations, accepting change, and encouraging creative, participative contributions from all employees.

Dr. Rodney E. Hanneman
Vice President
Corporate Quality Assurance
and Technology Operations
Reynolds Metals Company

There is no question that Reynolds Metals Company's McCook Sheet & Plate Plant produces some of the finest aluminum plate in the world.

During the past six years, Reynolds has invested \$1.3 billion in its plants and equipment, with over \$125 million of this going to improve quality and productivity in the McCook Plant. This plant's impressive plate capabilities were upgraded with the addition of three major pieces of equipment including a numerically controlled 5-axis skin mill.

Steps taken by management over the past few years to ensure a quality product are paying off today. Our McCook people are justified in the pride they feel in the product they produce.

T. N. Brown
Vice President & General Manager
Mill Products Division
Reynolds Metals Company

Reynolds Metals Company is a vertically integrated aluminum producer, with activity spanning the entire range of the aluminum process, from the discovery and mining of bauxite, through the production of finished aluminum products for a broad variety of industrial and consumer markets, to recycling. Domestically, Reynolds operates 47 plants in 19 states and employs 37,000 people.

Reynolds McCook Sheet & Plate Plant, located in the southwest Chicago suburb of McCook, has an average of 1700 employees and a payroll of over \$50 million annually. The McCook Plant is the

largest plant in the State of Illinois under one roof—70.4 acres on a 290-acre tract. It was built by the U.S. government in 1942, leased by Reynolds in 1946, and purchased by the company three years later.

The McCook Plant produces a wide variety of coiled and flat sheet and plate. The sheet is sold to a variety of customers for further processing into such products as aluminum cans, various applications in the auto and truck industry, building products for siding and roofing, and appliances. The plate is machined for such uses as the Space Shuttle, and for wingskins and wing components for such commercial aircraft as the McDonnell Douglas DC-10 and DC-9 Super 80.

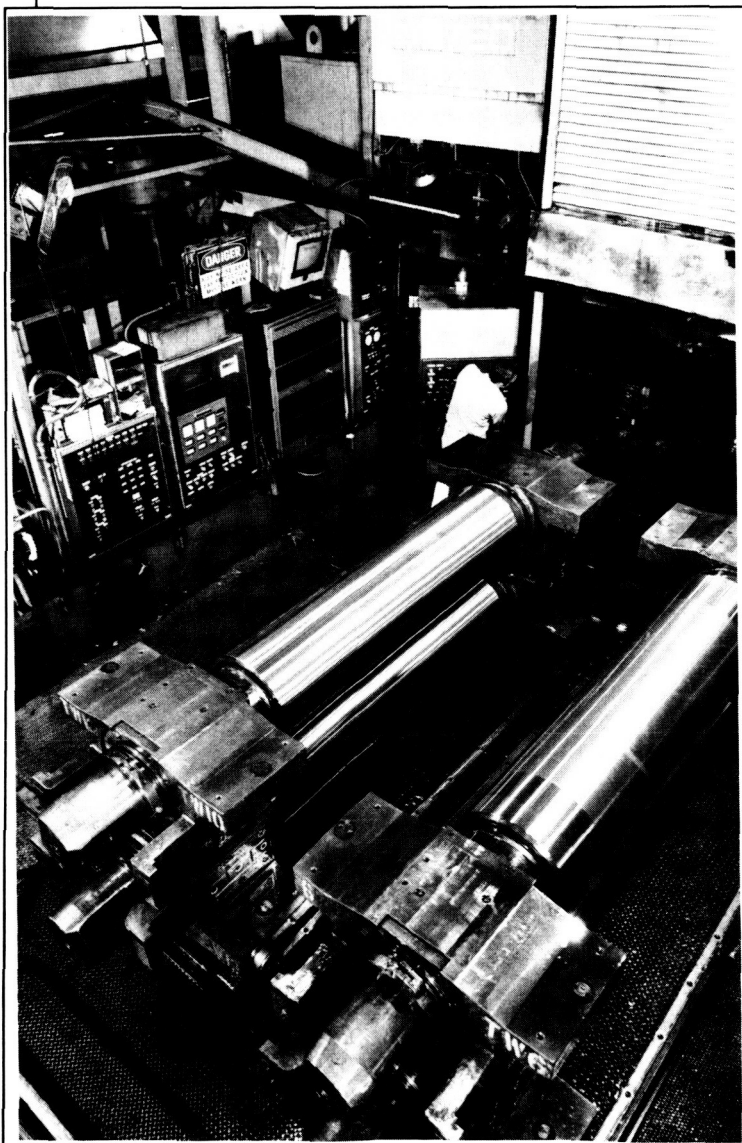
Since 1980 significant steps have been taken at the McCook Plant that will assure excellence in quality and productivity throughout the decade. Modernization of this 44-year-old facility includes state-of-the-art equipment for rolling and leveling sheet products and for heat treating and machining plate products.

Employee participation has become a way of life with the inauguration in 1981 of the Reynolds Metals Company's CHAMPS (Cooperative Hourly and Management Problem Solving) program. This program assures a voice in quality and productivity improvement from all levels of employment. Reynolds Metals Company has supported plant quality enhancement with its corporate quality action and communication programs.

During the past six years, Reynolds Metals Company has invested \$1.3 billion in its plants and equipment. Over \$125 million of this has gone to improve quality and productivity in the McCook Plant.

The heart of McCook's coiled sheet equipment modernization is a new cold rolling mill that is one of the most advanced aluminum sheet mills in the world. This single stand four-high mill can handle coils up to 40,000 pounds and can

McCook's cold rolling mill is readied for a work roll change. The mill is designed to allow changing of the rolls in 3-1/2 minutes.



The tension leveler/cut-to-length line at McCook can tension level at speeds up to 1,500 feet per minute. It can operate at 300 feet per minute in the cut-to-length mode.

roll aluminum sheet to final thicknesses of .006 to .100 inch in widths from 36 to 77 inches.

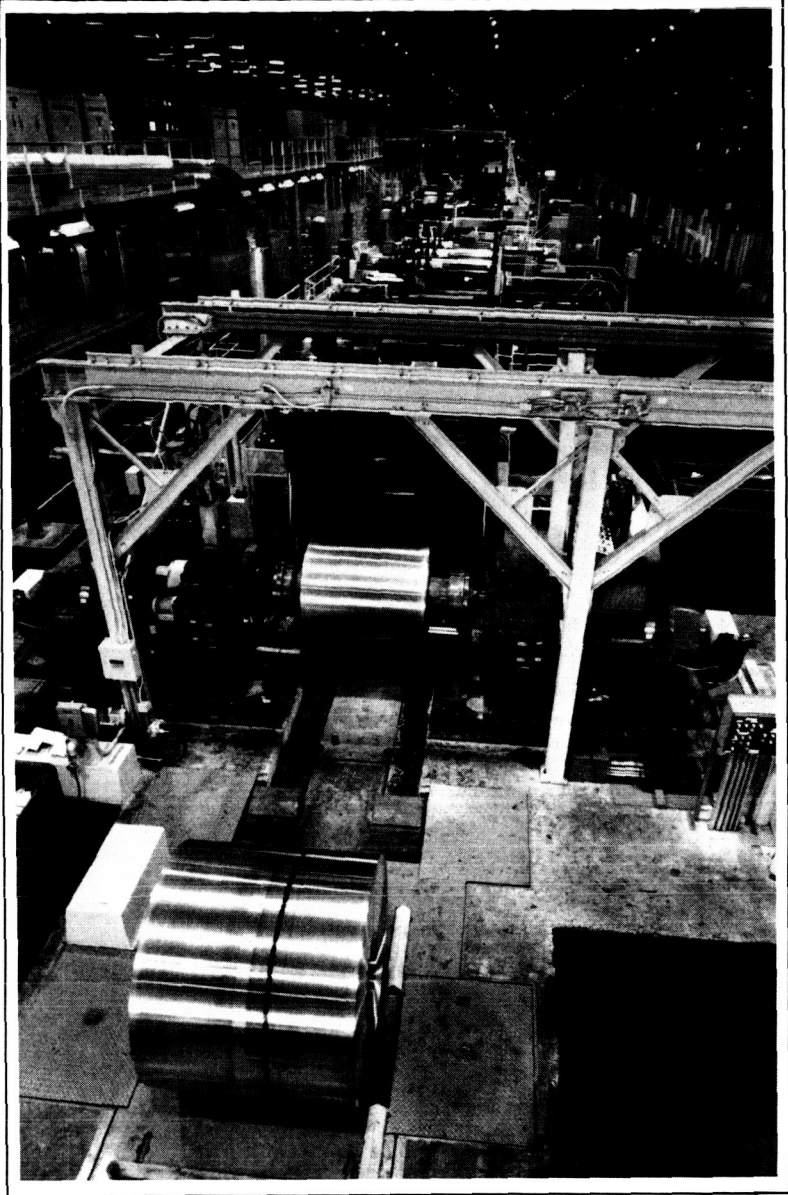
The 8000 hp mill is almost completely automated. The operator enters a coil number, and the operation is taken over by the mill's bank of eight computers. The correct coil is selected from an inventory area and brought to the mill for rolling. While the coil is being rolled, automatic hydraulic gauge control and automatic shape control systems assure minimum variation in thickness and an exceptionally flat sheet. The new mill is augmented by a 2000 feet per minute slit and a leveler/cut-to-length line capable of continuously leveling coil while it is under tension of up to 100,000 pounds.

McCook's already impressive aluminum plate capabilities have been upgraded with the addition of three major pieces of equipment. These are a horizontal-type heat treater, a plate saw, and a numerically controlled 5-axis skin mill.

The new horizontal roller hearth conveyor plate heat treat line can heat treat aluminum alloys in gauges from .250 inch up to 6 inches. It will accommodate plate widths up to 119 inches and lengths up to 80 feet, with travel rates varying from 1.75 inches per minute to 200 inches per minute. The entire unit is 452 feet long, with an 88-foot load table, 180-foot furnace, 90-foot quench, and 94-foot dryer and unload conveyor. It is serviced by two new 20-ton double hook overhead cranes.

McCook's new plate saw is designed to precisely cut aluminum plate up to 40 feet long and 10 feet wide. It is equipped with two 100 hp heads. Each head operates at 1800 rpm and is capable of handling saw blades 32 to 36 inches in diameter. One saw head can rotate plus-or-minus 181 degrees in order to cut irregular shapes.

This saw is designed for feed rates up to 400 inches per minute and rapid traverse up to 960 inches per minute. It is controlled by a numerical controller with



on-board computer. The operator, whose cab travels with the saw, has the option of entering data to the saw manually.

The new double gantry skin mill is one of the most sophisticated computer controlled milling machines in the world. It is the newest of eight skin mills at the McCook Plant.

Aluminum plates resting on the 222- by 20-foot bed (which makes this the largest such mill in the United States) are held in place by a vacuum system.

The gantries are capable of running three vertical spindles. Each gantry has five axes of travel:

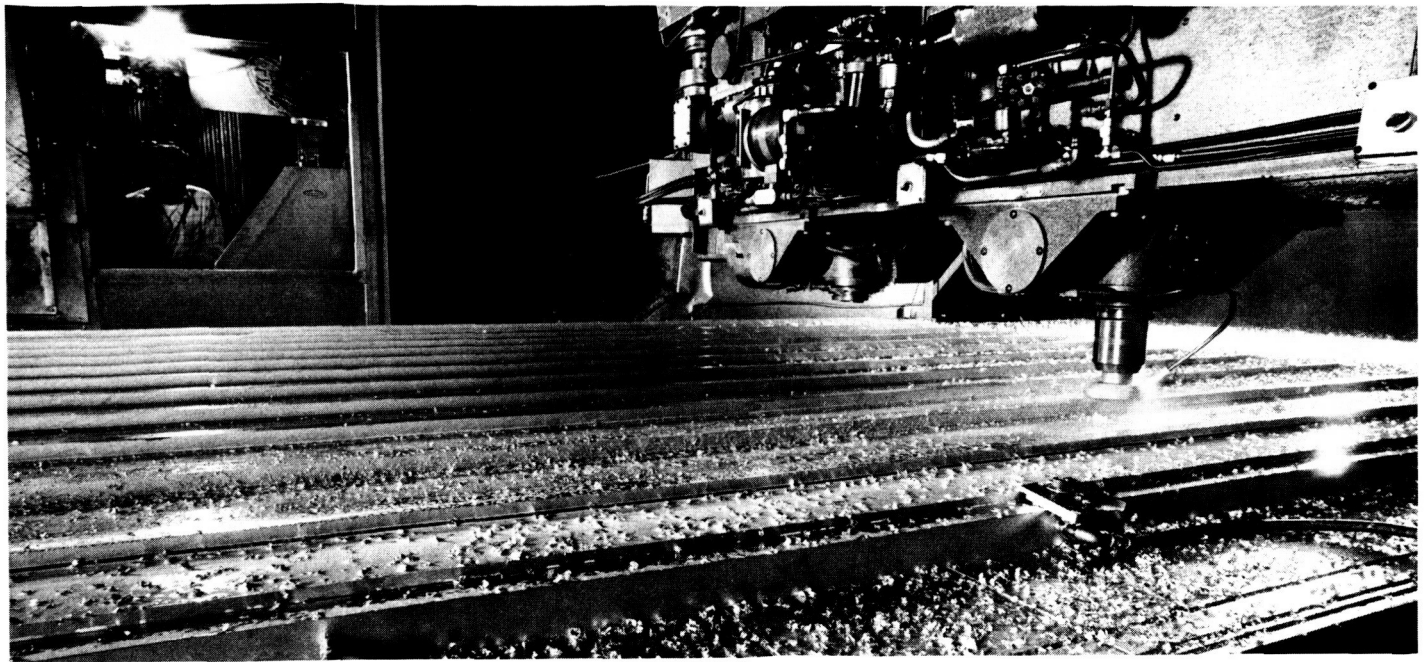
X: 1833 inches longitudinal

Y: 136 inches transverse

Z: 18 inches vertical

A: plus-or-minus 20 degrees swivel

B: plus-or-minus 20 degrees swivel



Each aluminum panel for the Space Shuttle's external fuel tank starts as a 5,500-pound aluminum plate. Machining removes almost 5,000 pounds.

The mill is controlled by an Acramatic computer numerical control system, with all programming performed in-house by Reynolds personnel.

Reynolds is currently machining the aluminum for the external fuel tank of the Space Shuttle, as well as wingskins for the McDonnell Douglas DC-9 Super 80, on this mill.

Since mid-1981 the McCook plant has been using a new approach to management called CHAMPS. This is a modification of the quality circle concept that has proved so successful in Japan and in some other companies in the United States. The philosophy behind the CHAMPS program is very basic and very simple. It is based on the premise that the people doing the job know best how to do it better.

CHAMPS is made up of teams from all areas of the McCook Plant. A team is a small group of employees from the same working area who voluntarily meet for an hour each week to discuss work-related problems, investigate causes, recommend solutions, and take corrective action when authority is under their control. Key points to the program are:

- People-building philosophy.

- Voluntary membership.
- Problems not just identified but also investigated and solved.
- Training provided to both members and management.

The CHAMPS program gives employees a chance to participate in making changes to their jobs. It creates a vehicle to open communication between employee and management. Through the CHAMPS program we have improved our quality, reduced product cost, and improved employee morale.

The CHAMPS team program affirms that management believes the individual doing a job knows more about it than anyone else and that, given training in problem-solving and the opportunity to use it, the individual will suggest changes for improving his job. Nearly all people will take more interest and pride in their work if they are given the opportunity to influence decisions made about their work.

CHAMPS is not limited to hourly and production workers. Staff and support functions have CHAMPS teams as well.

In CHAMPS' first four years, CHAMPS teams proposed 467 solutions, 393 of which were approved and implemented. The total savings on these projects was eight times their cost. One out of every

five McCook employees is on a CHAMPS team.

The continued support of Reynolds Metals Company's quality enhancement programs has assured steady progress in this area at the McCook Plant. Early in 1982 the company reorganized its Quality Assurance management team. This reorganization included the appointment of a Vice President of Corporate Quality Assurance. Two highly visible actions that came with the new quality organization were the initiation of a Quality Action Program and a Quality Communication Program.

The Quality Action Program included a significant increase in the emphasis on Statistical Process Control. The McCook Plant, which had been using SPC in some areas, began widespread training of employees in the use of SPC in the fall of 1982. By the middle of 1985, 250 employees had received an average of nine hours training each.

To actually get control charts started on the shop floor, one variable was chosen from each of 13 major departments. This gave a broad base of exposure to employees throughout the plant. Today about 90 control charts are in effect. A Quality Specialist is assigned full time to review each chart at least once a week. Each out-of-control point is investigated and corrective action is taken to prevent recurrence.

The primary objective of the Quality Communication Program is to create

awareness and understanding of quality as a priority corporate thrust among managers and employees. Other objectives are to show customers that Reynolds is committed to quality, to recognize and encourage quality from suppliers, and to create a public awareness that Reynolds is a quality aluminum company and a quality employer.

The slogan, "Our Quality Shines Through," and accompanying logo have become familiar to all Reynolds employees. They appear on most of the printed material used within the company. The communications program was kicked off by showing a 12-minute videotape to all employees and distributing packets containing items such as bumper stickers and decals with the quality logo. Follow-up has included posters and paycheck inserts featuring pictures of Reynolds employees stating their reasons for believing quality is important at Reynolds.

In an era when smokestack industries appear to be in trouble in America, the Reynolds McCook Plant is making significant achievements in the areas of productivity and quality. Between 1982 and 1985, the pounds shipped per employee was more than doubled. Over 2000 Space Shuttle fuel tank panels have been supplied to Martin Marietta's Michoud Division without a single rejection. We are proud to have been selected as a finalist in the 1985 NASA Excellence Award for Quality and Productivity. □

Members of the CHAMPS team "motivators" received jackets in recognition for their analysis and proposals for solving 20 problems.



Rockwell International

Space Transportation Systems Division

Productivity and Product Quality Improvement

Rockwell has produced quality products to support NASA's space programs for several decades. We are committed to improving on this fine record. We have progressed well on a plan for productivity and product quality improvement. The main objectives are:

Determined top management commitment and leadership to improve the quality of our products/services.

Systematic improvement in our methods and procedures for providing effective support of our business activities.

Consistent opportunities for our employees to use their talents and creativity to improve productivity and product quality and to become "partners" in the process.

Aggressive development and capital investment for acquisition of state-of-the-art technology.

We are continually reviewing and improving our efforts to support these objectives. The process is one of learning, of change. We welcome this opportunity, initiated by NASA, to share the highlights of our activities and to learn from others. This will assist all of us in meeting industry commitments to best benefit our nation, our customer, and our employees.

R.A. Petrone
President
Space Transportation
Systems Division
Rockwell International

Rockwell has produced systems of pioneering importance to the national space program—from single-mission aircraft to a fleet of reusable orbiters. As one of NASA's original contractors, we developed and built the X-15, the research craft flown repeatedly to the fringes of space, paving the way for extended space flight. Later, when the nation committed to a manned lunar landing, we commenced the Apollo program. We developed more than half of the major hardware elements in the Saturn V/Apollo stack that culminated in nine flights to the moon, three Skylab missions, and the Apollo/Soyuz linkup in space.

Now, with national space interest turned from space exploration to space utilization, our Space Transportation Systems Division is the primary builder of the Space Shuttle orbiter, the world's only reusable spaceship. Our work on the Space Shuttle program is covered by several NASA contracts. Under the basic contract and schedules thereto, we have designed, developed, and built the four orbiters for the Shuttle fleet. We also provide integration support to NASA for the Shuttle system, support the logistics effort, assist Shuttle users with the development and integration of their payloads, and provide realtime operations support for Shuttle missions.

The Space Transportation Systems Division (STSD) believes the major ingredients in improving productivity and product quality are the commitment, vigorous leadership, and involvement of top management. Our policies have been developed to include top management quarterly reviews of Productivity and Product Quality Improvement (P&PQI). We have infused the P&PQI process into every organization throughout the division. We firmly believe that the success of the process is the responsibility of line management.

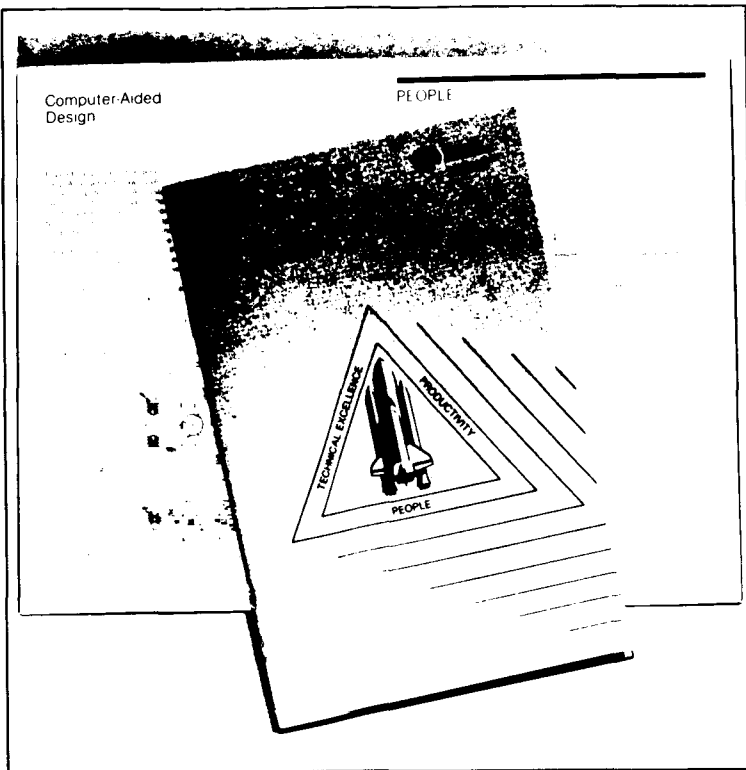
For this reason quarterly reviews are held with our president and his immediate staff, which precipitate similar regular activity in each department. A broad agenda permits us to assess the many excellent improvements

taking place in our division without over-control. Each management council member presents examples of accomplishments and plans in each of the following three areas: (1) improvements in product/services quality, (2) more effective ways of doing business, and (3) improvements in work environment/climate. The number of items each member presents is limited to those that fit within the one day allotted for the review. The president chairs the meetings, and only persons directly reporting to him are permitted to make the presentations. The reviews are well into their third year.

Function heads are given considerable latitude in how they organize their P&PQI efforts to promote the broadest spectrum of ideas and activities. In their reviews they apply several different methods which work in parallel and support the overall STSD productivity and product quality process. All methods, however, entail the development of tangible Improvement Plans which are entered into our computerized system. Improvement Plans are indexed and tracked until completion. Open and closed plan information is furnished as well as overall participation and the benefits obtained. Plans are identified for gainsharing where the concept may be applicable to other functions or departments. The use of the same Improvement Plan format in all reviews facilitates understanding and similar application of the improvement process.

Since reviews are held at multiple levels throughout STSD, there is an emphasis on eliciting improvement ideas that pertain to work-center activities from floor-level personnel. Ideas are discussed with supervision and, if accepted, become documented as formal Improvement Plans. Teams or individuals (employees and/or management) are assigned to develop the improvements. Improvement Plans become "contracts" to pursue solutions. This method has brought the top management commitment to P&PQI down to floor-level employees. Representative samples of these plans become the subject of higher level reviews.

A unique approach for implementing P&PQI has been initiated in our engineering department, called the Triad of Excellence. It organizes desired improvement emphasis areas into a work



Phantom organization leads Engineering Triad of Excellence to technical and human resource improvements.

Many improvements cross functional lines and thus utilize councils made up of expertise from various functions. One good example is our Product Quality Improvement Councils (PQIC) which attack hardware problems within each production operations department. These PQICs are co-chaired by managers from each manufacturing department and Quality Engineering, and are supported by the most knowledgeable individuals from Engineering, Material, Tooling, and Planning. The councils meet at regular intervals with the agenda determined by upcoming production items that have histories of manufacturing difficulties.

The PQICs can act expeditiously, as the approved minutes constitute authority to remove obstacles to production of quality hardware. Results of PQIC actions are contained in Figure 1. This concept has been enthusiastically received by manufacturing and engineering personnel and by NASA and Rockwell management. It has also been extended to many of our subcontractors and suppliers.

The engineering and production operations examples described are representative of the approaches taken

breakdown structure. The Triad is composed of three major segments: Technical Excellence, People, and Productivity. Each segment is broken down into specific functions, or "trees," which in turn become the subject matter for Improvement Councils. Each council is led by a key member of management, who, in addition to his or her regular duties, directs the activities of the council. This "phantom organization" meets regularly to achieve objectives. Various options are developed, and the council is tasked with recommending and implementing approved actions. This method is now applied in other functional areas.

Figure 1

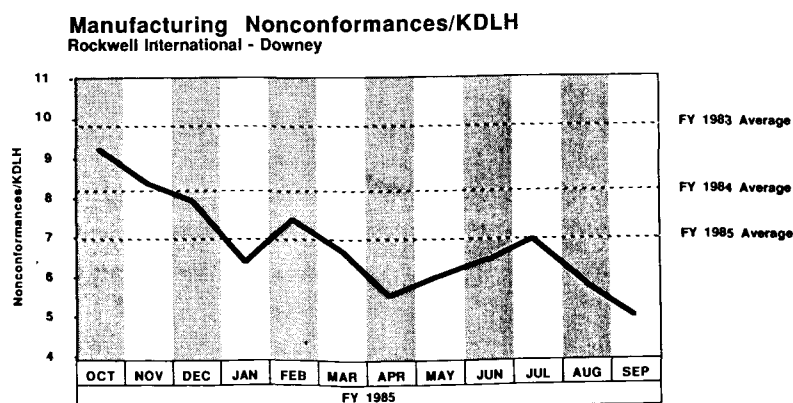
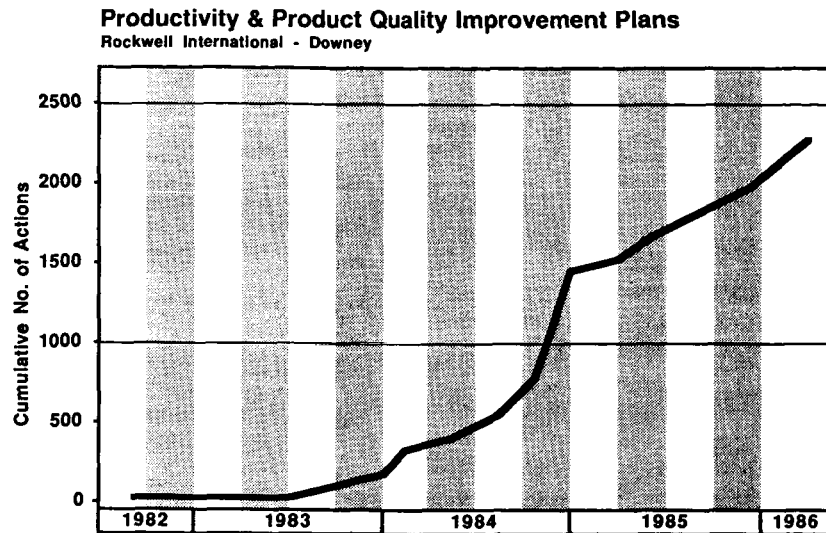


Figure 2



across the STSD to implement improvement in productivity and product quality. Our process provides for a broad base of activities structured both by top management and by application of the ideas and skills of our floor-level personnel. The reviews provide the leadership and involvement which promote continued expansion of our process. Our growth has been excellent; more than 2300 Improvement Plans have been identified through the various activities (Figure 2).

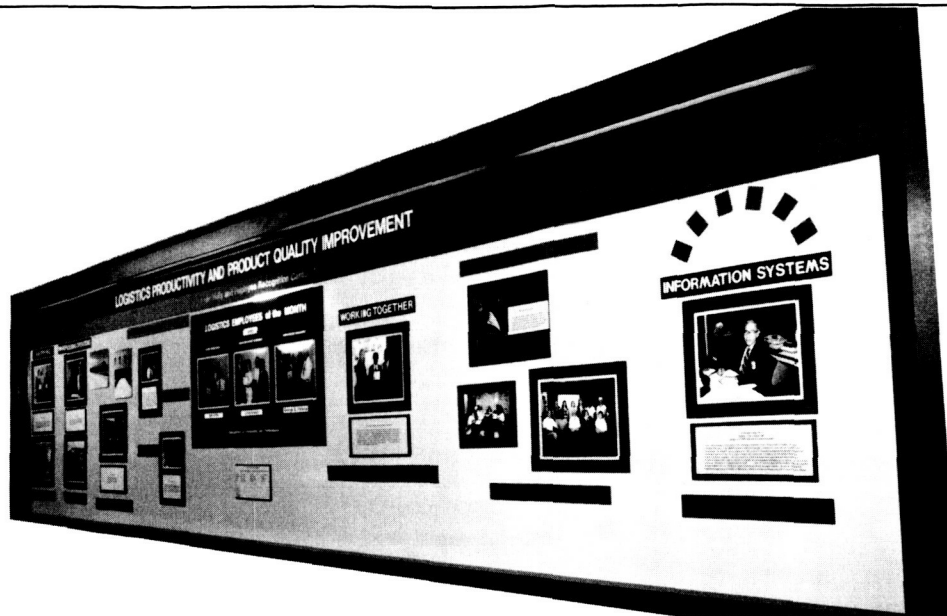
Our commitment to improving our productivity and product quality through the involvement of our people is supported by an ambitious capital investment plan. A summary of some of the highlights follows:

- Machine shop modernization with the installation of 45 computerized numerically controlled machines—36 funded by Rockwell, 9 by the government.
- CAD/CAM expansion with terminals in over 70 locations and productivity gains as high as 400 percent in selected areas.
- Artificial intelligence applications now in progress.
- White-collar automation with all functions accessed to mainframe computers as well as expansion of personal computers and electronic links leading toward paperless systems.
- Automated Management Information Center (AMIC) which enables briefing and

other information exchanges with NASA at a great saving of time and cost.

As we took steps to involve our employees more in decisions affecting their work, we realized we should supplement existing methods of communication, training, and recognition. We have given each employee a booklet describing his or her role in entering proposed improvements into the P&PQI system. We realized our training program needed to be expanded to increase skills in group process, problem-solving, and team/individual motivational techniques. We have included these in our management and PQIC course syllabus and have offered special training for Employee Action Circles. We also offer the "Investment in Excellence" videotape series to our employees. We have placed considerable emphasis on recognizing the accomplishments of employees who are participating in the P&PQI process. In most function areas we have established Employee Recognition Centers or Displays where the teams and individuals actively contributing are portrayed and their accomplishments described. Related performance measures and other motivational materials are also displayed.

As we pursued our current P&PQI effort with its emphasis on employee participation, we did not want to entice short-term gains through a "carrot and



Product Quality Improvement Councils play a major role in improving in-process quality.

Team and individual participation produce a dramatic increase in the number of improvement plans.



stick" awards program. Now that our process is more mature, we are emphasizing motivational awards as additional incentives.

Our company has a tradition of step-by-step evolutionary development of systems and procedures to build and integrate complex products and services. While our P&PQI process is ambitious, it must progress within this framework. We felt it was important to

target our changes in controllable segments with a high probability of success. By building on these successes, we have been able to produce marked change in the division culture. Change is difficult. Every change threatens someone: someone's authority, someone's privileges, someone's status. Our feedback indicates that we have made great strides in improving teamwork and pride. There is much more to be done; in fact, we feel productivity and quality improvement never ends. □

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